METAL INDUSTRY

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Brickbats

CRITICISM, and well-deserved criticism at that, is levelled against the metal finishing industry in a recently published review issued by the British Productivity Council which states that in general, managements have evaded their responsibilities. Process and production requirements rarely receive that broad review which it is the function of higher management to take. As a result, possibilities of improvement are too often discarded on such grounds as first cost where a longer view would show that the initial cost might eventually effect an overall saving. Dealing with the case where metal finishing is carried out in a tied works, the report states that although some managements seem to have recognized finishing as being an integral part of production, too many still treat it as an afterthought. In support of this statement a case is cited where by slight modification of a press, so as to round the rims of the large number of holes in a particular mass-produced article, a saving of £200 a week was effected in an annual paint bill of £78,000.

In the electroplating industry the majority of firms, despite the advances that have been made in production techniques, and new methods, still follow the traditional pattern of the industry and their process controls show no signs of modernity. Indeed, this lack of precise process control is, perhaps, the most noticeable shortcoming in the plating industry. There are, however, also many other points which could receive wider attention. Work study, for example, is a term hardly known in the industry, while plant maintenance is often indifferent. While recognizing that jobbing platers—who, incidentally, are estimated to handle between 35 and 50 per cent of the total work plated in the country—often have to deal with short runs and therefore are unable to apply manufacturing methods which would bring down costs, the report chides them because they have no system of standard costing, and, indeed, in many cases no system of costing whatsoever; their prices depending for the most part on what the market will bear. For this last situation, of course, those of their customers whose overriding concern with a low price seems to blind them to the fact that a low price plus consumer-dissatisfaction plus higher servicing charges do not, in the end, add up to cheapness, must be held partly to blame. Plant and equipment suppliers, also, are not exempt from criticism. There is a general grumble that control equipment is not what it should be; thermostats are said to be insensitive and meters often inaccurate. Again, while there is a general call in the industry for oil-cooled transformers, many equipment makers persist in supplying air-cooled transformers.

Progress, uneven though it may be, has been made, however, in the techniques of production and in the preparation of materials promoting faster finishing. There has been an improvement in the surface finish of rolled steel sheet available in this country. The manufacturers claim that they can supply whatever surface quality is required by users, provided economic quantities are ordered, and this is certainly true as regards surfaces for organic finishes although platers may still have cause for complaint. Agreement is general that the surface finishes of zinc-base pressure die-castings have improved. The report also deals with alloy plating, mentioning particularly the process developed by the British Iron and Steel Research Association for the deposition of an alloy of zinc and iron which has successfully withstood severe weathering tests. This process has not as yet been taken up by industry although the alloy may be used as a base for chromium. This may be due to the reluctance of the industry to explore the possibilities of alloy plating. On the other hand one large firm operating its own research and development laboratory states categorically that its experience with all the alloys it has tried out as substitutes for nickel confirm its belief that none of them possesses its desirable attributes.

Out of the MELTING POT

Listening In

IN view of the wide choice and ready availability of the transducers, amplifiers, and indicating and measuring devices that could be adapted for the purpose, it is surprising why the promising electro-acoustic method of studying phase changes in alloys has hitherto failed to find any wide acceptance. Essentially, the method involves the use of a suitable pick-up to listen to the "noises" that accompany phase changes in alloys, viz. melting or solidification, and the transition through the liquidus, solidus, eutectic and the limiting solid solution temperatures. Acoustic effects occur only when the particular changes are accompanied by a reduction in volume. Depending on the nature of the change and the rate of cooling (or heating) there can be observed characteristic differences in the number, intensity, frequency and form (wave shape) of the acoustic effects. While attempts to use these characteristics as evidence from which to deduce views as to the nature and mechanism of the changes occurring in the metal seem as yet to be a little premature, there can be no doubt about the more direct basic value of such evidence. Thus, for example, the electro-acoustic method provides a simple means for an accurate location of the solid solubility line and for a study of its displacement with increasing rate of cooling. Another interesting result of observation made with the aid of the electro-acoustic method on the lead-tin alloy system is the evidence of the formation of some sort of sub-nuclei at temperatures well above the liquidus or melting point. Thus, in the case of pure lead, the first effect, which is considered to indicate the start of the formation of these sub-nuclei, was recorded at a temperature 16°C. above the melting point of the lead. With increasing additions of tin, this temperature range above the liquidus tended to widen, reaching a maximum at the eutectic composition where the first effect occurred at a temperature 42°C. above the melting point. In the case of pure tin, the first acoustic effect indicated the setting-in of sub-nuclei formation at a temperature 37°C. above the melting point.

Two Birds

ENOUGH has been said about the problems besetting the retrieval of information to permit no uncertainty regarding the size and complexity of the task. What it has completely failed to do is to draw attention to the way in which these problems reflect on the manner in which the information is recorded in the first place. The manner in which information is recorded is such that a great deal of work has to be done in order to achieve some limited degree of certainty of being able to trace some particular information. All this work is necessary for the simple reason that the purpose of recording and publishing information is, first and foremost, to make it available there and then in the most adequate form, whereas its availability in the future, if it is considered at all, is very much of a secondary consideration, any periodical, author and subject indexes notwithstanding. There may be various opinions as to the degree to which the recording of information succeeds in its primary purpose. There remains to be considered if, and, if so, to what extent, it can be modified to simplify the purpose of making its retrieval simple and efficient. Are, in fact, these two purposes compatible? Information recorded for ease and completeness of retrieval may prove quite unsuitable as a means of conveying that information to those concerned with it when it is first made available. Conversely, it is not impossible that the difficulty of retrieving information recorded in the usual way simply points to the fact that such information is not really worth retrieving any way. How often have those who have engaged in retrieving information experienced disappointment at the results of their labours? The growing evidence seems increasingly to point to the fact that information recorded and made available for information cannot be intended or subsequently adapted for storage and future retrieval. Material for these latter purposes must be of a fundamentally different nature and must be routed along an entirely different course. Indeed, here as elsewhere, desirable though it may be, it is likely to prove impracticable to kill two birds with one stone.

Direct Labour

AS a change from playing about in electronics, electrons have recently been finding themselves being put here and there to the performance of sterner and more direct tasks. It would be by no means premature to undertake a review of these tasks, even though some of them are, as yet, hardly beyond the laboratory stage. The object of such a review would be to draw attention to the possibilities of the jobs that can be done by electrons and to lead to a consideration of the lines along which their further development could be directed. Such a review would be greatly simplified by the fact that the jobs to which electrons have been put have the common factor of being based on the utilization of the heat generated when a beam of high speed electrons impinges on a metal or other material. Jobs for which such electron beams have already been used include electronic melting, electronic welding, and electronic machining. The electron beam is derived from an incandescent tungsten coil; it is accelerated by the application of a suitable voltage, and focused by known means. At first sight an inherent drawback of these electronic processes might appear to be the need to carry out the operations in a high vacuum. This "drawback" does mean, however, the absence of all risk of contamination, and also the removal of many impurities from any metal that is melted in the course of the process. Modern industrial high vacuum technique, moreover, successfully reduces it to easily manageable proportions. Indeed, the time cannot be far distant when the performance of metallurgical and metal working operations in a vacuum, or in some kind of controlled atmosphere, will be the rule rather than the exception. So far as the processes themselves are concerned, it is interesting to note that they fall into the category of "bit-by-bit" processes recently referred to. (See this page, METAL INDUSTRY, 23 May, 1958, p. 422.) The bit-by-bit electronic melting process could be readily extended into a bit-by-bit casting process, in which the metal would be progressively melted and the molten metal at once cast and resolidified progressively to build up a casting of the required shape. In electronic machining, the possibility of moving the electron beam and/or the work, and of removing the unwanted (molten) metal by the application of electrostatic, magnetic or electromagnetic pulses, or of centrifugal force, opens up some interesting prospects.

Skimmer

POTENTIAL DEVELOPMENTS IN HIGH TEMPERATURE ALLOYS

Niobium in Aircraft Gas Turbines

MANY current aircraft, powered by gas turbine, turbo-prop, jet, rocket or ramjet engines, demand higher operating temperatures for certain parts if their speeds are to be increased further. This is emphasized by the fact that as flight speed increases from Mach 1 to Mach 4, the turbine temperatures will rise about 540°C. (1,000°F.).

High temperatures, therefore, are needed for high speed flight, for turbo-jets, for turbo-props and turbo-fans, and turbo-rockets, and the application of niobium in these fields was recently discussed by W. S. Hazelton, of Westinghouse Electric Corporation before a meeting of the Society of Automotive Engineers.

In general, the turbine components are exposed to the most severe combination of temperatures and stresses, and are the hardest to cool effectively because of their mechanical complexity; present turbine materials have been designed for use up to about 1,100°C. (2,000°F.). This is totally inadequate for many applications which must be considered today in gas turbines.

The problem of developing and selecting high temperature materials for aviation gas turbines is more difficult in some respects than that facing designers for other propulsion equipment, such as rockets. In general, aviation gas turbines are used for manned aircraft, where absolute dependability is mandatory. The complexity of the rotating parts and the design problems require that the materials have ductility and toughness. Although these requirements can be lowered by ingenious design in some cases, little use can be made of ceramics, cermets and other materials so useful in many other types of high temperature equipment. Therefore, metals and alloys must be developed with the necessary high temperature properties.

If hopes of radical changes in the nature of atomic bonding by physical alchemy, are excluded, the job of developing high temperature metals can be broken down into two problems. First, metals must be selected that will not melt at the desired temperatures, and secondly, alloys of these metals must be developed which will have and retain their usable properties at temperatures close to their melting points.

The metals with very high melting points are:

	Melting point °C.
Tungsten	3,410
Rhenium	3,180
Tantalum	2,996
Molybdenum	2,620
Niobium	2,478

Tungsten, tantalum and molybdenum have all been used for high temperature parts. Tantalum, tungsten and rhenium are all much heavier than niobium and molybdenum, which puts them at a distinct disadvantage from the important aspect of strength-weight ratio. Although these elements are necessary for temperatures near and above the melting point of niobium and molybdenum, the much lower densities of the latter elements make them the most attractive for aviation gas turbine structural applications.

Strength and Ductility

Very little is actually known yet about the strengths ultimately attainable in either molybdenum- or niobium-base alloys, but available data can be used to good advantage. Possibly because molybdenum alloys have been under development longer, the better molybdenum alloys show a distinct superiority in rupture properties. However, it must be admitted that the niobium alloys show a marked advantage over one of the better conventional alloys, Inco 713C. With the present emphasis on the development of niobium-base alloys, it can be confidently expected that alloys with properties approaching those shown for the best molybdenum-base alloys will be developed.

The modulus of elasticity must be considered in many applications, and in parts subjected to bucking loads it is often of prime importance. In this respect, molybdenum is far superior to niobium. Although the low modulus of niobium is a serious disadvantage, it must be remembered that alloys of aluminium and magnesium have been used for important structural parts, even though they have very low moduli. Furthermore, there are some compensating advantages to this low modulus.

Thermal conductivity and expansion are often very important in determining the durability of a high temperature part. High temperature parts very often fail by thermal fatigue caused by cyclic stresses induced in the parts when they are heated and cooled. The magnitude of these thermal stresses is directly related to the thermal expansion, conductivity and elastic modulus of the material. Both molybdenum and niobium can be expected to have excellent thermal fatigue resistance because of their low coefficient of thermal expansion. Although molybdenum has a higher conductivity, niobium's lower modulus will tend to offset this and the materials should both be resistant to thermal fatigue.

Designers of aviation gas turbines require ductility in their materials. When alloys of the high melting point elements are investigated, a particular kind of ductility problem associated with the body-centred cubic crystal structure of all of these elements is encountered.

Iron, chromium, tungsten, molybdenum and niobium are all subject to a phenomenon known as the ductile-to-brittle transition, which is dependent on grain size, impurity content, temperature, and strain rate. This means that alloys of these elements are brittle and will break when cold and/or under impact loading. Metallurgists have learned to minimize this phenomenon by alloying in the case of iron and steel, but the problem is always present in the elements mentioned above.

As the temperature of testing is lowered, these metals change their flow and fracture characteristics. The yield strength increases, and the mode of fracture changes from a ductile shear type to the brittle cleavage type.

Oxidation Resistance

With the exception of special gas turbine apparatus, such as turbo-rockets, the high temperature parts of aviation gas turbines are subject to a highly oxidizing atmosphere. Again nature seems to be against the metallurgist, because all these high melting elements that have been considered have practically no oxidation resistance at the temperatures of the desired applications. Molybdenum is particularly poor, because its oxide, MoO_3, becomes volatile below 540°C., and above 785°C. comes off in clouds of white smoke. From a practical standpoint, niobium is not much better, although its oxide is not volatile.

There are two approaches that can be used to overcome this difficulty. For example, the poor oxidation resistance of iron can be helped greatly by alloying it with chromium and other metals. This approach has been tried on molybdenum with no practical success. Sufficient protection of molybdenum parts has been achieved by various coatings and claddings to make

TABLE I—THERMAL CONDUCTIVITY OF NIOBIUM AND MOLYBDENUM

Properties	Molybdenum		Niobium	
	Condition	Value	Condition	Value
Thermal conductivity B.Th.U/ft²/hr/°F/in.	212°F	800	212°F	377·5
Thermal expansion in/in/°F. × 10^{-6}	RT-1800°F	3·4	RT-1800°F	3·8

it useful for many applications, but these give only temporary and somewhat unsatisfactory results. Turbine nozzle vanes, fabricated of Inconel-clad molybdenum sheet, were engine tested more than 30 hr. with very satisfactory results at temperatures over 1,100°C. Niobium can be protected in a similar manner. The problem of protecting niobium is much less severe, partly because its oxide is not volatile, and minute imperfections in the coating are not as deleterious. The most significant difference between molybdenum and niobium is the possibility of developing an oxidation-resistant alloy of niobium with adequate mechanical properties. Several investigators have already developed niobium-base alloys with excellent oxidation resistance up to 1,230°C., and even better alloys can be expected.

Fabrication

Obviously, if a material is to be useful for structural components it must be fabricated easily, using practical techniques. Molybdenum can be forged into useful shapes, using proper control of the temperature and amounts of reduction. It can also be rolled into bars and sheets. There is no apparent evidence of increased difficulty with niobium. In fact, experience indicates that less troubles will be encountered. One of the important aspects of proper fabrication of molybdenum is the necessity for fairly close control of residual cold work in the metal. With molybdenum of commercial quality, and with the alloys available now, a residual amount of cold work representing about 50 to 70 per cent reduction is necessary to give the required strength and ductility. Too little cold work will make the molybdenum both weak and brittle, while too much will lower the recrystallization temperature, reducing its strength at temperatures over 1,100°C.

To obtain this optimum amount of cold work, molybdenum alloys must be recrystallized at the proper point in the rolling or forging cycle and final reduction to size accomplished at temperatures ranging from room temperature to 1,320°C., depending on the particular alloy and final product. Die design and forging sequences must be especially controlled in the manufacture of intricate forgings to ensure correct amounts of reduction throughout the finished part.

Probably the first niobium-base alloys to be commercially available for structural parts will also be strain hardened, and will require controlled amounts of cold work to give them desirable properties. Limited experience with niobium alloys indicates that close control may be required until alloys are developed which do not depend on work hardening for their properties. Little is known about forging techniques, but the higher general ductility of niobium permits most rolling operations to be accomplished at or near room temperature.

Forming sheet metal is one of the most important fabrication jobs that must be considered for aviation gas turbine parts. Both molybdenum and niobium are readily formed by the normal techniques, but molybdenum often must be heated to 320°C. to 540°C. for severe forming. Indications are that this may not be necessary with niobium. This is not a serious disadvantage, because such warm working is normal practice in many magnesium and titanium fabrications.

Joining is a more serious problem. Welding by such processes as inert gas shielded arc will cause the weld metal to pick up gaseous impurities, such as nitrogen and oxygen. These can seriously embrittle both molybdenum and niobium. Many problems remain unsolved in the field of welding both molybdenum and niobium, but the embrittlement problem seems to be of a much smaller magnitude in niobium.

The molybdenum alloy vanes mentioned previously are excellent examples of accomplishments with molybdenum. The parts were stretch formed of Inconel-clad molybdenum at 320°C. to 425°C., and the trailing edge tack welded by resistance. The trailing edge joint and the exposed edges were micro-brazed to effect joining and protection of the sheared edges. No difficulties were experienced with any of the processes.

Cost and Supply

For many years niobium has been considered a comparatively scarce element. Uses of niobium were minor, and production was very small. During World War II niobium was high on the list of strategic materials and strict controls on its use were necessary. At the time of the Korean War, use of niobium was again strictly controlled by the U.S. Government. As an example of these rigid controls on the use of niobium, an objective of a maximum usage of 0·35 lb. of niobium per 1,000 lb. of thrust was set for turbo-jet engines by the Defence Department. Since that time, extensive deposits of niobium ore have been found. Known reserves in 1955, for example, were 10 times as great as during World War II.

The advantages of the low modulus of niobium were mentioned previously. Other things being equal, a low modulus will permit more alloying without serious loss of ductility. There are two reasons why this tolerance for alloying elements is of primary importance. First, it allows high percentages of elements imparting oxidation resistance to be added to niobium without reducing ductility to an undesirable level. Secondly, it permits greater flexibility in designing alloys for high temperature strength.

Since strengthening of commercial molybdenum and niobium alloys by cold work is lost by recrystallization, the usable temperatures are limited by the recrystallization temperature. Also, the recrystallization temperature it lower with more cold work, thus making the strongest alloys useful as the lowest temperatures. It is most desirable, therefore, to develop alloys which are not dependent on cold work for their strength.

Creep, the problem at high temperatures, is caused by two types of dislocation movement, "glide" and "climb". It is impossible to increase the resistance of a metal to creep by interfering with either or both of these types of movement. Dislocation glide can be retarded by introducing interfering particles by precipitation. This is common with conventional age-hardening alloys.

Dislocation climb, the movement of a dislocation around an interfering particle, is related to the rate of diffusion. Adding solid solution elements with low diffusion rates can be expected to slow down dislocation climb and increase creep strength. Thus, since niobium should tolerate more alloying, it will permit the strengthening of its alloys by both important mechanisms. Therefore, it is felt that the possibilities for the development of a strong, oxidation-resistant alloy are very good.

Obituary

Dr. C. H. Desch

WE regret to record the death of Dr. Cecil Henry Desch, F.R.S., superintendent of the Metallurgy Department of the National Physical Laboratory from 1932 to 1939.

His posts included appointments at the Metallurgical Department of King's College, London, Glasgow University, the Royal Technical College, and Sheffield University. In 1943 he became a director of Richard Thomas and Company Ltd., resigning when the company was amalgamated with Baldwins Ltd. He was subsequently associated with the Whitehead Iron and Steel Company.

He was elected F.R.S. in 1923, President of the Faraday Society in 1926-28, and the Institute of Metals in 1938-40. He was awarded the Bessemer medal of the Iron and Steel Institute in 1938. In 1946-48 he was President of the Iron and Steel Institute.

Mr. R. W. Sanderson

WE also regret to record the death of Mr. Roger Whaley Sanderson, of The General Electric Company's Research Laboratories at Wembley.

Mr. Sanderson gained an honours degree in physics and chemistry at Birmingham University, did research work there for the Department of Scientific and Industrial Research, and joined the staff of the G.E.C. Research Laboratories in 1923, where he later took charge of a newly-formed group working on corrosion problems. He was a member of the Electrochemical Society of America and of the Institute of Metal Finishing.

MERITS AND APPLICATIONS OF SELF-LUBRICATING BEARING MATERIAL

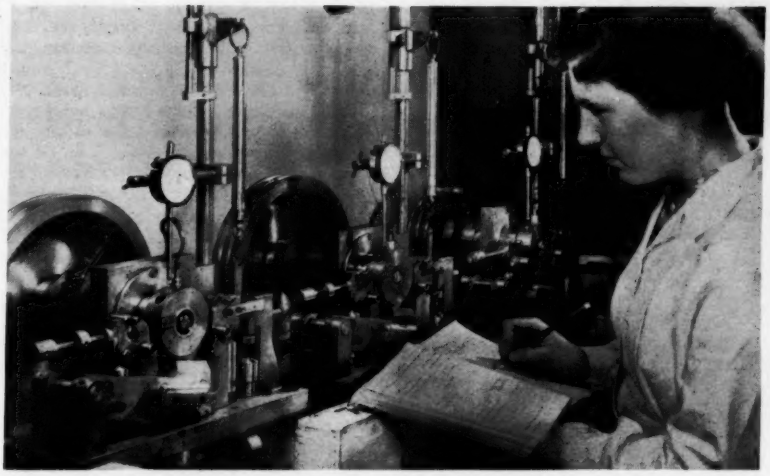
Plastics Impregnated Sintered Bronze

IN the mass, polytetrafluoroethylene is a waxen white, odourless and tasteless, inert solid of relatively high melting point, with an extremely low friction coefficient. Porous sintered bronze bearings, impregnated with P.T.F.E., have advantages where bearings must operate for long periods without replenishment of lubricant, and where oil or grease may be objectionable or unable to withstand relatively high temperatures. Bearings of this type, designated "Polyslip," now being made by Bound Brook Bearings Ltd., have a porous bronze matrix impregnated with P.T.F.E., and have a superficial layer of P.T.F.E. on the bearing surface. This layer is only 0·0005 in. thick and is provided for the initial period of operation (running-in) during which the layer of P.T.F.E. is transferred to, and forms a thin film over, the bearing surface of the shaft or journal.

When the layer is transferred to the journal, P.T.F.E. runs on P.T.F.E., and there is no metallic contact. If a deficiency of the solid lubricant occurs —usually by wearing away of the P.T.F.E. film—the local rise of temperature causes expansion of the P.T.F.E. in the porous lattice of bronze and it extrudes to the surface. Replenishment of lubricant causes the local temperature to return to normal, and the film of P.T.F.E. on both the bush and journal surfaces is re-established.

There are three types of Polyslip, and each type is available in two different grades. These grades are designated A and B, wherein the first is fully impregnated with P.T.F.E. while the other, Grade B (intended for less onerous duties) is only part-impregnated, and is substantially cheaper.

The types are numbered 1, 3, and 4. Type 1 bearings have compacted and sintered porous bronze matrices and, with few exceptions, are available in the same large range of sizes and shapes as the well-known oil-retaining bronze bearings made by Bound Brook Ltd.



Battery of wear testing machines at Bound Brook Bearing Co. These machines are equipped with dial gauges to show the progress of wear under pre-set loads

Type 4 bearings have matrices made from graded spherical bronze powder which is not subjected to pressure in the moulding (as are the powders used in making Type 1 bearings). After the sintering operation, Type 4 bearings are impregnated with P.T.F.E. in the same way as the other types.

Type 3 has been developed to overcome the physical and financial restrictions of the process by which porous sintered bronze bearings are made. These Type 3 bearings have solid bronze shells or dense sintered bronze backings to provide structural strength, with 0·030 in. linings of sintered porous bronze at the working surfaces. These porous linings are impregnated in the same way as Polyslip 1 and 4.

Research has shown that a rough guide to the performance of Polyslip bearings in any one of the Types 1, 3, and 4, is given by the PN value. This parameter is the product of the pressure in lb/in^2 and the shaft speed in revs/min. at which 1,000 hr. of life can be expected.

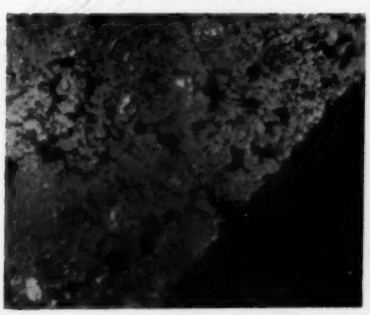
The following figures are averages of bearings of various types and grades operated in the absence of any liquid. The life or duty of these bearings is increased by the presence of water or other liquid in which the bearing may be wholly or partly immersed.

Type	Grade	PN
1	B	4000
1	A	7000
3 and 4	B	14000
3 and 4	A	18500

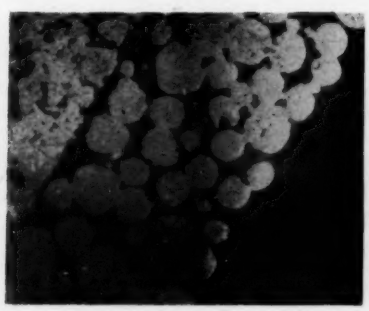
Certain substances, used as additives, have the ability to lengthen the life of a bearing impregnated with P.T.F.E., and research is being directed at evaluating the influences and suitability of these substances, with a view to even greater improvement of these self-lubricating bearings.

Photomicrographs of sectioned "Polyslip" bearings; the essential differences between the three types are clearly shown

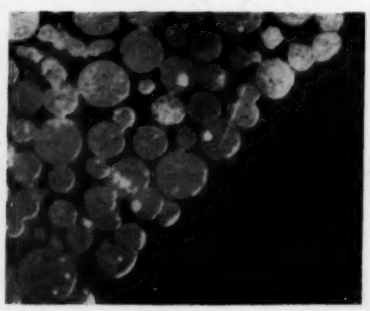
Polyslip 1 and 2



Polyslip 3



Polyslip 4



Readers' Digest

BEHAVIOUR OF CRYSTALS

"Dislocations and Mechanical Properties of Crystals." *Edited by J. C. Fisher, W. G. Johnston, R. Thomson and T. Vreeland, Jr. Published by J. Wiley and Sons, and Chapman and Hall Ltd., 37 Essex Street, London, W.C.2. 1957. Pp. xiv+634. Price 120s. 0d.*

THIS book comprises a collection of the Papers read at a Conference held at Lake Placid, in September, 1956. The material originally presented has in some cases been revised and amplified and short notes of the discussions on the Papers have been included.

Although the main purpose of the meeting was to discuss those aspects of dislocation theory bearing on the mechanical properties of crystals, other functions of dislocations are also described in some of the contributions. This is not surprising, considering the range of interests of those attending the Conference—Mott, Read, Frank, Nabarro, Seitz being among the names familiar to those who have any dealings with dislocation theory.

Some of the Papers describe a single experiment or present the outline of an idea, and are only a page or two long: others are sufficiently detailed and complete almost to justify an individual monograph.

The first section is entitled "Direct Observations of Dislocations" and contains eight contributions of which the four most important are by Amelinckx, Mitchell, Hirsch *et al* and Gilman and Johnston. The first two authors describe the decoration of dislocations in halide crystals, Amelinckx giving detailed analyses of the complicated networks revealed and showing that the nature of dislocation climb, of the climb of dislocation networks and of the effects of precipitates on dislocation movement can be studied by this method. The work of Hirsch and his colleagues at the Cavendish Laboratory on thin metal films and of Gilman and Johnston on lithium fluoride crystals give an interesting contrast of techniques and some of the questions posed by the results indicate that a new approach to several important problems, e.g., the theory of dislocation, nucleation, and of fracture, may be necessary.

A related topic—the relative influences of internal and surface dislocation sources is considered in the next section of the book and methods of assessing the effects of free surfaces on deformation processes are discussed. The types of deformation occurring in single crystals of copper and of aluminium are also described and include twin formation in copper crystals stressed at low temperatures.

The longest Paper occurs in the third section and in it, Seeger of the Max Planck Institute, Stuttgart, gives a detailed review of theoretical and experimental work on the dislocation mechanisms governing work hardening and recovery. He also considers the Bauschinger effect, creep phenomena and the effects of alloying additions. This is followed by other Papers on work hardening effects and then by a section devoted to the deformation of alloy crystals.

Internal friction and fatigue form the two main topics of the succeeding section, the principal contributors being Lücke and Granato, and Mott. The latter author's Paper on fatigue serves to emphasize the need for more direct experimental evidence on the role of dislocation in promoting fatigue damage.

In the sixth section, "Theory of Dislocations," the Papers are all fairly short and deal mainly with the energies associated with dislocations and with the effects of dislocation movement. These phenomena are also considered by Nabarro in the seventh section of the book, the subject of his Paper being the dekinking of whiskers. Other work on whiskers and small, thin crystals is also described in this section.

The final group of Papers deals mainly with the production of structural defects by irradiation and the influence of such defects on the properties of the material. Consideration is also given to the annealing of irradiated metals, a process which is governed by the damage incurred by the specimen.

It is clear that this book will be of great interest to those who have to keep abreast with the rapidly developing views on dislocation and deformation processes and lattice defects generally. They may be somewhat disappointed to find that much of the material has already been published elsewhere, but the general reader gains here, as many of the authors have been able to present a summary of their work, done perhaps over a number of years, in a full, coherent form. This must be one of the main justifications for the production of this expensive, permanent record of ideas which, in this changing field, the authors themselves may already have discarded.

J. M. B.

High Temperature Brazing Alloys

IN order to meet the demands of new applications in jet aircraft and the high duties demanded from gas turbines, new brazing alloys have been developed to cope with the demand of designers for an alternative form of joining other than welding, in particular one that would meet the rigorous specifications for high-temperature service.

Nickel-base brazing alloys have been developed to meet these new conditions; they have good high-temperature strength, resist oxidation, erosion and corrosion, and have good flow characteristics in inert atmospheres.

Details of four such alloys are given in Table I, all of which are manufactured by Dewrance and Company Ltd., Great Dover Street, London, S.E.1.

The highest in nickel and lowest in boron, Endewrance Alloy CM.50 is the most ductile of the group; it is recommended for joints requiring maximum ductility in an open joint.

Having particularly good flow characteristics, Alloy CM.52 is recommended for joints requiring maximum penetration, and is particularly good against attack from liquid sodium, mercury, and mercury vapour.

Very good wetting characteristics are also a feature of Alloy CM.53, but in general it is better than CM.52 for corrosion resistance.

Alloy CM.56 has the highest corrosion resistance but is not quite so fluid as CM.52 and CM.53 and, therefore, is more difficult to braze.

A hydrogen atmosphere is generally recommended for use with these alloys when brazing stainless steels, Nimonic 75 or cobalt-base alloys—burnt town's gas may be used for brazing mild steel, and vacuum brazing is essential when joining Nimonics 80 and 90. The brazing temperature should be at least 75°C. above the flow point.

The alloys are supplied as cast rods and powders; the latter can be mixed with acryloid resin to form a paste. The powder can also be applied by metal spraying equipment; this method is particularly suitable where close control is necessary.

The shear strength of a brazed stainless steel joint is well over 20 tons/in^2 at room temperature, and over 10 tons/in^2 at 500°C.

TABLE I—BRAZING ALLOY COMPOSITIONS

Alloy	Nickel per cent	Silicon per cent	Beryllium per cent	Chromium per cent	Flow Point in Dry Hydrogen °C.
CM.50	93·25	3·5	2·25	—	1055
CM.52	91·25	4·5	2·9	—	992
CM.53	82·0	4·5	2·9	7·1	996
CM.56	71·0	4·5	3·5	15·0	1030

Finishing Supplement

Institute of Metal Finishing

PROCEEDINGS AT ANNUAL CONFERENCE AT TORQUAY

(*Continued from* METAL INDUSTRY, 13 *June* 1958)

PARTS of the discussion on the Papers by T. P. Hoar and D. J. Arrowsmith, and by P. A. Brook, which were presented at the second session of the Annual Conference of the Institute of Metal Finishing at Torquay, were published in our issue of 13 June. The remainder of the discussion and the authors' replies are given here.

DISCUSSION

S. Watson (British Non-Ferrous Metals Research Association):

Hoar and Arrowsmith show typical restoring-force/thickness curves, and the point is made that stress appears first of all to increase and then to decrease. We get similar results with saccharin.

Regarding the comment about the different sorts of stress curves, the authors worked with condensed chemicals similarly related; all their stresses tend to decrease and they get a number of similar curves. Dr. Edwards mentioned that we had curves of other shapes and in particular one which falls and then increases and falls off again. That is not just one particular substance. A number of substances related chemically give a very similar curve, some narrower ones which go up and some wider, but they all show stress first falling and then increasing.

Dr. Edwards also briefly discussed the incorporation of substances which affect stress in the deposit. He mentioned that saccharin appears not to be incorporated. That not only is true, but last year we showed that the levelling action is obtained with, say, thiourea, depending on the concentration. If saccharin is added to the solution, the levelling is decreased at a given concentration. This seems to suggest that saccharin is not incorporated but hinders the incorporation of other substances.

Dr. Edwards' Paper contains some confirmation of this. The substance "M730" appeared to decrease the total concentration of the addition agents or organic materials in the deposit and therefore must reduce the concentration of the other substances, not just itself.

G. Storey (University of Birmingham):

Work on gas/metal equilibrium by Smith in the United States has shown that the interfacial tension varied little with the metals considered, and it was in the range of 500 to 2,000 dyne/cm². This is in agreement with Dr. Hoar's figure. Smith also showed that these tensions or energies did not vary much with temperature, as Dr. Hoar suggests.

If tensile stresses found in thin layers of deposits are due to the freezing in of residual tensions, since the interfacial tensions do not vary very much from one metal to another, would it not be expected that the stresses in thin deposits would be of the same order, whatever the metal considered?

It is well known that there is an order of magnitude in the difference between the stresses measured; for example, copper and silver show 3 tons/in², whereas nickel, chromium and iron give 30 tons/in². Would Dr. Hoar like to comment on this?

Dr. Hoar suggests that perpetuation of vacancies might occur through the deposit, but a vacancy is surely a very energetically favourable site to accommodate an atom, since in such a position it will satisfy many more bonds than would appear on the surface.

R. A. F. Hammond:

Brook's Paper notes that for the methods employed surface preparation has no effect on porosity in a deposit of the thickness used. This is supported by results on a wider range of electrodeposits by Blum and his co-workers. Nevertheless, the result seems surprising, and the author is wise to express his final conclusion in cautious terms.

In this connection, is not the difference between, say, 8R and the electropolished surface a case of the difference in surface crazing? Wide discrepancies in porosity are shown in many of the series. Is the autoradiographic porosity itself reliable? Does it function for deviating pores or only for those pores which present a straight uninterrupted path through the deposit? Have any attempts been made to check the radiographic results by conventional chemical porosity tests?

If the test is reliable, how does the author account for the wide variability within the series? Could this be due to variations in the number or size of oxide inclusions in the tough pitch high conductivity copper the author used?

Have any attempts been made to correlate or compare the mean density of inclusions per unit of the area with the typical mean density of pores after plating?

Dr. S. Wernick (Consultant):

Brook's main finding is that porosity is independent of the method of preparation.

How does this result arise? There might be some explanation if it is postulated that one of the principal ways in which porosity is produced is as a result of uneven rates of deposition locally. In other words, there is the basis metal, and because of some condition of the surface, whether organic matter which has not been properly cleaned or foreign matter or oxide, the growth is not equal. A condition then occurs where there are possible sites of pores.

It does happen that most methods for removing grease probably achieve a minimum degree of cleaning which is satisfactory and which will obviate the effect just described. If this is so, any minimum method of cleaning is satisfactory. What seems to have happened after Brook's examination of the various cleaning techniques he has looked out is that all his methods are too good. So there is this somewhat negative result which is in a measure unfortunate, because there is no yardstick by which to judge any of the cleaning techniques.

Dr. H. J. Pick (University of Birmingham):

A sharp radiographic image of a pore will only be obtained if it is perpendicular to the surface, irradiated by a beam of radiation parallel to the pore itself. Only under these conditions will there be a very marked difference of absorption in the rays coming through the pore and through the solid metal in normal radiographic techniques. In micro-radiographic techniques one usually uses X-rays with an energy of 35 kV. Is not the decay scale for the radioactive nickel used in these experiments pretty high? In this case the sensitivity will be much lower than 2 per cent.

If this picture is true and a pore which is inclined to the surface is unlikely to show up except in a very diffuse way, the other difficulty which might arise is connected with the following fact. If the porosity were caused by some fault in the surface itself, if we have a fault which continues and the radioactive nickel is not deposited, there is no source of radiation for darkening the pore which is continued through the subsequent deposit. This might lead to some difficulty in picking up discontinuities of this type.

Dr. D. N. Layton (Ionic Plating Co. Ltd.):

In practice, porosity varies a great deal with surface preparation, and Dr. Wernick is right in saying it is largely tied up with cleaning. If the cleaning is not perfect, the effects of the mechanical preparation underneath become evident and there are variations in thickness. As Dr. Edwards pointed out, the nickel does corrode in practice, and with this effect there is a pore.

There are then, three explanations for the lack of correlation between Brook's conclusion and our practical experience. First, there is the straightforward variation in thickness; second, there is the straightness of the pores; and third, there is the retention of grease in roughly abraded surfaces which may not be cleaned out in practice. Perhaps they were in Brook's experiments. It is most important that an attempt should be made as early as possible to correlate the results of the autoradiographic technique with other porosity tests.

S. W. Baier (British Non-Ferrous Metals Research Association):

What is the relationship of this porosity. The nickel is 0·001 in. and the order of pores per square inch is 3, 4, 8 or 10. In the early days when Hammond and Hothersall used to talk about porosity on nickel plating on steel, the idea one had at the back of one's mind was that with a thickness of 0·001 in. on steel one was just getting away from the porosity. There was only the odd pore here and there and that was being affected by the surface of the basis metal. Later on, one said possibly some of these were not pores at all.

In those days no one would have said any reasonable nickel deposit plated as, say, 0·003 in. or 0·005 in. on copper, prepared by any reasonable method, would be non-porous. Is there not something quite different about this radiographic technique?—is it really testing pores at all or is it somehow making some signs through crystal boundaries or something quite different?

E. A. Ollard (Atlas Plating Works):

Has Dr. Hoar considered the possibility of depositing not on an adhesive, a prepared metal surface, but on what in the trade is sometimes called a film surface, a surface with an oxide or some other coat, so that the deposits do not adhere?

We daily deposit ten circles of nickel 0·010 in. thick on a surface where they do not adhere. They are then stripped off and they lie perfectly flat on the table. They have to. If a de-stressing agent is used these things have to be heat-treated and they would not be sufficiently ductile, so nearly always if organic material is used and the deposit is heated in any way there is trouble.

It can be done by very careful purification so that a solution is obtained which is as free as possible from any sort of organic or other foreign metal.

Mr. H. Silman (Electro-Chemical Engineering Co.):

The definition of porosity can be very largely determined by the method used for assessing it.

In Brook's Paper there were objections to the various methods which are employed. The ferroxyl test results in corrosion which creates porosity. It might be argued that the gaseous diffusion test is absolute, because if there is a pore, the gas will penetrate through it. But even that does not follow, because it may well be that the inclusions in the deposit in the form of loose particles which are known to occur may allow gas to diffuse through and cause the appearance of a pore.

In the same way, the results obtained in this Paper, which are of a fairly high order of porosity, may well be determined by variations in the penetrability—if it may be so called—of the deposits.

By the radio-active process, therefore, measurements of porosity may well be regarded as being empirical and related to the type of technique used. One should not take too much notice, therefore, of the figures themselves, when comparing one process with another. If a particular method of measuring porosity is consistently employed, comparable results can be obtained.

Care should be exercised about the use of the term "pore", because there is no indication that pores in the sense of true holes going right through a deposit do exist to any large extent when thicknesses of the order described in this Paper are being considered.

H. D. Hughes (Metachemical Processes Limited):

For any quantitative results obtained from the authors' method, even though they are working on smaller thicknesses and on smaller possible variations in grain size, to be effective the control of the basis material is imperative. Qualitative results and comparison results will require control from sample to sample. Quantitative results are required on the measurement of the grain sizes, and some definition of orientation is required before the results are published.

On the effect of addition agents, our experience would tend to confirm the work on this subject. A proprietary addition agent was used on a small number of experiments, and using the micrographic method there was a reduction in compressive stress. There was an increase in hardness, taking nickel up to 800 to 900 V.P.N. with a big reduction in flexibility and impact resistance. The experiments were discontinued for that reason.

AUTHORS' REPLIES

Dr. T. P. Hoar: Dr. Edwards rightly pointed out that the present Paper deals with relatively few results. Eighty-six experiments are reported in it, and we did several hundred. Also there is a great deal in the literature on the measurement of overall stress which makes the same point we were trying to bring out—that stress can be changed over in a continuous way from tensile to compressive stress by the addition of certain addition agents.

As Dr. Edwards said, if we added a lot more even of the stress-reducing agent, it might become a stress-increasing agent. There is no question but that several effects come in with any one substance; not only that, for as well as brightening, levelling and stress reduction or increase, any one or other of these properties may be altered in a continuous way. In certain cases there is first an increase and then a decrease, then another increase and so on.

The whole problem of adsorption and stress is a highly complex one, about which only a little is understood.

It is doubtful whether saccharin has no effect on cathode potential. In a Paper to this Institute some years ago it was shown to have a certain effect. Saccharin may not be incorporated to any extent in deposits, it probably becomes absorbed and desorbed rather quickly but at the same time during deposition there is undoubtedly an effect of saccharin in stress reduction, as is well known.

As to the possibility of making compressive deposits in nickel without organic addition, it seems certain it can be done. Hughes' compressive deposits may be due to operating the solution at reasonably high *p*H. He has said privately that his compressive nickel was obtained from a plain Watts bath, *p*H 5.2. One would undoubtedly get some nickel hydroxide or oxide, and there may have been some in the deposit acting as stress-reducing agents. The same thing would probably have been found with our Watts bath, but it was deliberately operated *p*H 4 throughout to get the minimum amount of oxide formation consistent with the minimum amount of hydrogen evolution which might upset the cleaning effect of the nickel deposition itself. If a Watts bath is operated at a high *p*H nickel hydroxide is incorporated, and quite apart from any other effect a much lower tensile may be produced, or possibly, even compressive stress.

With regard to the preparation of the steel basis metal to which Hughes called attention, we used a fairly good alkaline degrease and a very light pickle. When the copper flash was put on before the nickel, no effect on the subsequent stress was noticeable. Nickel plating after a copper flash on this steel gave precisely the same results, whether it was compressive or tensile, as though the flash was not there. That is surprising, and one wants to go a lot further into the effect of the basis metal on deposits.

Under our conditions (not Hughes') after the "steady-state stage" has been reached, it seems certain that we have nickel deposited on nickel, and the grain size has no very great effect.

That must be remembered when Hughes is speaking of grain size.

His deposits are similar to ours and everyone else's in having a very fine grain size indeed in the as-deposited condition, which is important from the point of view of stress. Obviously if there is recrystallization at a high temperature the stress relationships and the dislocations that possibly cause them are completely altered.

It is interesting to see that his deposits are very hard. That again leads to the conclusion that quite a lot of material is incorporated that is not metallic nickel. How could one have metallic nickel of that hardness without something in it which is preventing the slip one gets in ordinary nickel?

With regard to Watson's point that the substitution of one atom in a stress-reducing agent, S for O, in substituting thiocarbonyl or carbonyl groups, can have a very large effect, of course it does, because the adsorption of thio-substances is always a lot greater on any surface in a general way when the same substance contains enough oxygen or thiourea or urea or any similar substance. The fact that this major effect is obtained is not in the least surprising. We tried thiourea; and the results were peculiar. The stress reduced and increased again in the way Watson and Dr. Edwards have observed. But it was also found that there was a lot of decomposition of a hydrogen sulphide form with thiourea at *p*H 4 and the results were not significant.

With regard to Storey's point about the surface tension of metals, most metals give surface tensions in the range of 250 to 2,500 dyne/cm., and the fact that there is far more stress in nickel, iron and cobalt deposits than in silver and copper is entirely consistent with and supports the present idea. The Paper only said that a fraction of the stress can be frozen in. The harder the metal, it is fairly clear, the more effective is the freezing in process.

With relatively soft metals like silver and copper one would expect a small amount of freezing in to occur at the same current density, with a lot of freezing in in the case of the harder metals, nickel, iron and cobalt, because the equilibrium between surface and bulk will be more nearly achieved for copper and silver than for the harder metals.

Storey's point about the perpetuation of vacancies is a good one. At first sight, one would think a vacancy on the surface was just the spot for an atom to sit down in. So it is, from the point of view of the most stable position. From the point of view of the most stable position, the atom could go into the vacancy. But from the point of view of the position it will go into kinetically this does not occur at all, because it may need more activation energy to go into a hole in the surface than to sit down outside the hole. It is a matter of kinetics rather than equilibrium, as are so many of these things. It is reasonable to postulate the perpetuation of vacancies in the formation of edge dislocations.

The question about depositing on an oxide film surface is interesting. We have not done any on stainless steel or anything similar. If a nickel deposit is stripped from such a stainless steel and it lies flat and does not curl up one way or the other, this is good evidence that the overall mean stress is nil. There seems no reason why it should not be if, indeed, one is operating at *p*H 5. We operate at *p*H 4.

You get nil stress with no organic matter in the deposit. But it is doubtful if you could get a pure metal deposit which has not some tensile stresses. It must be the oxide which is wedging it up.

P. A. Brook: Dealing with the apparently high values of 13 and 14 pores per square inch, the point surely is that in most nickel plating there is a disturbed solution and these solutions were not disturbed. It is not stated in the Paper, but it should be realized that when there is no mention of stirring, that means nil stirring. One reason for not stirring is the difficulty of getting conditions of stirring exactly the same on every occasion. But there is no doubt that some gas pores did form.

Another reason for these apparently high values is this. Some calculations which were made showed that if there is a discontinuity of some description going about one-third of the way through a deposit, the plate deposited will be increased by a factor of two over the background. This is quite sufficient for someone to pick up and count as a full pore.

As Jones said, it is indeed difficult, but the only alternative to putting them on the screen and counting them is the very difficult and tedious scanning with a microphotometer. This is not at all an easy job.

These two factors together will easily account for the high values.

With regard to the measurement of pores, with a deposit of one-third thickness, 0·0003 in., there would be *n* pores per square inch, and pores would be picked up to a lesser extent but nevertheless they would be picked up in a deposit of 0·001 in. thick. On the type of discontinuity, Silman hit upon the answer.

All the methods of measuring porosity are empirical and the results depend to a great extent on the method of measurement. All that can be said is that anything which came through the X-ray illumination was picked up.

Jones mentioned the ferricyanide reagent always found to attack nickel. "Ferricyanide" refers to ferricyanide/chloride solution. This may have been misleading, but it was not done deliberately.

Jones also mentioned the use of an external source. The probable reason for my results was that a much thicker copper basis was used.

Jones is afraid that the presence of the radio-active nickel would affect the porosity of the nickel. How can this occur? The chemical and physical behaviour is so little different that nothing can be expected on that score.

The whole point of Fig. 1 is that no trace of discontinuity at all can be found. One would surely expect that if the radio-active nickel had some effect on the porosity, one would have seen discontinuity of some description at the boundary.

According to the Paper by Hothersall and Hammond, their surface roughnesses are much greater than mine since they used a file. I have worked with the coarsest emery paper and even then there were surface roughnesses. This is a point brought out in the Paper.

At the moment no attempt has been made to check my results with other methods of porosity measurement, but these things take time and it is under consideration at the moment.

As to perpendicular pores, there will be some pores perpendicular to the surface and some at various angles to the surface. These will be statistically distributed about a perpendicular line and the proportion of pores in quite a small angle can be worked out quite easily.

The whole point of this Paper is that it does not matter whether or not the ones not perpendicular to the surface are taken as long as a statistical sample is used.

The main criticism appears to be that the results are high, but it was pointed out in the introduction that they are meant to be comparative and not absolute, and that is the importance of this Paper—the comparative results.

Several speakers said they were surprised that surface preparation had no effect on porosity. It was pointed out that this can be explained easily by the fact that my surfaces are too clean. I have not kept any grease or dirt on them. Again, in Table II it was pointed out that when the surface is prepared by method 3 with one particular reagent the values are higher, and by ensuring that these surfaces were clean, the values were got back to all the others. Surely this is the answer.

The Chairman then thanked the authors and those taking part in the discussion and drew the session to its close.

(To be continued)

TECHNICAL SERVICE FACILITY FOR PAINTS DIVISION OF I.C.I. LTD.

Paint Evaluation Service

COMPREHENSIVE technical service facilities for the Paints Division of Imperial Chemical Industries Limited are provided by a new Technical Service Laboratory building at Slough. Advice on painting specifications and techniques, demonstrations and training are available for customers. Practical trials of new products and new techniques are also carried out in this building. Closely linked with the Technical Service Department is the Colour Advisory Department. The new building was designed as a main single storey laboratory block with a two-storey administration wing, the latter housing the managerial and administration staffs of the Technical Service Department on the ground floor and the Colour Advisory Department above.

Technical Service Laboratories

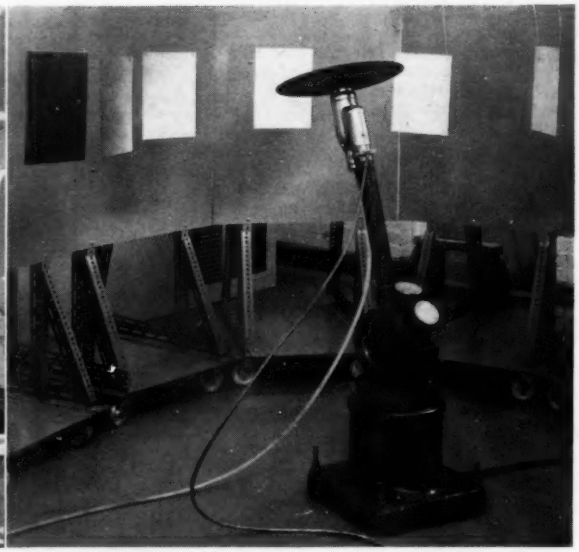
The pretreatment section includes a laboratory for the trial of new chemical-treatment processes, and two tank rooms for practical trials and demonstrations.

The larger tank room has a trichloroethylene degreasing plant, together with 20 tanks of up to 150 gal. capacity in which the various established "Deoxidine," "Granodine" and "Alocrom" processes can be demonstrated to customers on quite large articles. These tanks are mostly heated by steam, thermostatically controlled. There are also two experimental cabinets for the application of spray-applied pretreatments.

The other tank room contains a number of smaller tanks, which can

The industrial finishing shop houses the latest finishing equipment. Shown here are the three large water-washed spray booths, one of which is equipped with a hydraulic platform for lifting articles to be finished. The partitions are removable so that any large articles can be handled

Work on established or new metal pre-treatment processes is carried out in these experimental tanks of the pre-treatment section



The electrostatic spray plant, showing the spinning disc used in the Ransberg No. 2 process

be used for various experimental work with established or new pretreatment processes.

The industrial finishing section includes a main application shop, with separate rooms for flow-coating and electrostatic application, an oven room with various stoving devices, and a separate room for the training of customers' staff and other personnel, and separate rooms for wood finishing.

The main feature of the application room is a bank of three large water-washed spray booths covering a total width of 24 ft., with movable dividing partitions. Provision is made for the raising of heavy articles for spraying by means of a hydraulic lift.

Hot-spray plants are available, and an airless-spray equipment which applies the paint at a high temperature and at great pressure, relying on expansion and evaporation to provide atomization.

For dipping there is an adjustable apparatus to withdraw articles from a dip tank at various speeds adjusted for each individual need. A full-sized curtain-coating machine can be used for the very rapid coating of flat or near-flat parts.

In a separate side room there is a laboratory flow-coating machine for small articles, particularly useful in determining the suitability of a particular paint for this method of application.

The electrostatic plant is housed separately, with adequate safety precautions. It includes a mechanical conveyor line which can take panels up to about 3 ft × 2 ft., and all three methods used in the Ransberg No. 2 process—spinning disc, cone and bells—can be demonstrated.

One end of the oven room is occupied by a hump-backed conveyor oven, gas-fired, with variable-speed conveyor. There are two forced-convection box-type ovens, large enough to take a washing machine or a medium-sized refrigerator, also gas-fired. For small work there are a number of electrically-heated laboratory ovens.

A rectangular overhead conveyor passes through three different types of radiant-heat ovens, one electric and two gas-heated, all capable of carrying panels up to about 4 ft × 2 ft.

The trainee room is equipped with a large spray booth and offers full facilities for the training of both I.C.I. personnel and nominees from customers.

A large area is devoted to wood-finishing—mainly concerned with the furniture and radio cabinet industries.

The transport section covers work for motor car manufacturers, car refinishers, industrial transport vehicles and railways. There are two separate rooms, apart from the facilities for trainees, which are shared with the industrial section.

The decorative and marine section provides technical service and practical evaluation in connection with all paints used for the protection and decoration of every kind of building or structure, as well as for ships and boats.

Colour Advisory Department

The Colour Advisory Department is housed in the Technical Service building, but has a largely independent function in the encouragement of good painting by choice of colour. Colour schemes are prepared for the use of architects, local authorities, and large organizations, for the decoration of new and existing buildings—schools, hospitals, churches, civic buildings, factories and offices.

Standard Specifications

Continuously Hot-Dipped Galvanized Plain Steel Sheet and Coil (B.S.2989: 1958). Price 3s. 6d.

SIX classes of galvanized plain steel sheet and coil thinner than 0·118 in. with a maximum width of 48 in., and coated by the continuously hot-dipped galvanizing process from coil produced on a wide strip mill, are specified.

The six classes are divided into two groups. For one group the specified weights of zinc coating vary from 2·5 oz/ft² to 1·5 oz/ft²; for the second group the zinc coating is lighter, but the product has additional fabricating properties.

Steel sheet and coil in the first group are subject only to the test for coating adherence. This group is intended to provide a high degree of protection against corrosion of the parent metal. In general, the product will be used as flat sheets, although it can be bent to a limited extent.

The first class in the second group is intended, from the point of view of coating weight and bending properties, to meet requirements between those suitable for sheets normally used as flat sheets and those for material for severe bending. The remaining two classes in this second group are intended to provide for severe bending in subsequent fabrication.

The standard specifies dimensional tolerances on sheet and coil, as well as detailed tests for the determination of coating weight and coating adherence.

Copies of the above-mentioned standard may be obtained from the British Standards Institution, 2 Park Street, London, W.1.

INFORMAL DISCUSSION ON PRACTICE OF COMPACTING AND SINTERING

Developments in Powder Metallurgy

(*Continued from* METAL INDUSTRY, 20 *June*, 1958)

DEALING with the queries that had arisen during the discussion, the authors' replies published here bring to an end the report of the proceedings at the meeting, held a short time ago, by the Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals.

AUTHORS' REPLIES

M. Donovan: Oliver referred to our graphite furnaces. A new one is now being installed, a vacuum brazing furnace, identical in design to a sintering furnace and capable of going to 1,500°C. It is expected that the temperature distribution will be about ±10° at 1,300°C. The shielding system consists of two molybdenum shields backed by stainless steel.

Another furnace in our laboratories, similar to the one to which Oliver referred, has been operating at 2,000°C. and has molybdenum shields. The working space is about 1.' in. diameter by 12 in. deep.

The question of temperature distribution is very important. In this second type of furnace, at 1,300°C., sintering Nimonic materials, it has been ±5° consistently, and it is possible to hold that temperature under those conditions almost indefinitely. The reason is that if the screen assembly is in good condition, what amounts to an integrated sphere is obtained, and there is no reason, apart from end effects and so on, why there should not be a good distribution. When the screens become severely contaminated in course of time, the temperature distribution may become a little worse, but this has not been found to be serious.

In our later type of heaters it is hoped that the distribution will be improved considerably.

For the continuous furnace a series of lock devices could be used, as Oliver points out. This is fairly common in melting now, where one has one's working part in a chamber and at the side a couple of locks with valves which lift up and down, and the same on the other side. One opens the door with the valve closed, introduces the charge, pumps it out to vacuum pressure or high vacuum, opens the other door and the charge goes in, and the same procedure is used for taking it out. That should be possible, and, in fact, furnaces have been designed to do this horizontally or vertically.

An induction furnace plant is very expensive. Coil voltage is a very important point in flash-over. With resistance furnaces it is possible to have multiple set-ups or, in other words, a number of pots running off a common vacuum system and a common electrical supply, so that his point about induction plant being able to deal with a number of furnaces is not peculiar to induction gear. Throughput is the vital question in sintering.

Dr. Marshall mentioned the removal of lubricants, and it would seem that there would be contamination with oil in the oil type of diffusion pump. This may be an embarrassment, and it may be necessary to use the dry type of pump, or do the treatment in two stages, isolating the diffusion pump, removing the lubricant, and then carrying on with the high vacuum system.

Jackson referred to cost. If a process demands vacuum a little extra cost is inevitable, but it is not quite so expensive as is often thought. The larger the furnace, the less the relative cost; as the size goes up, the cost does not go up *pro rata*. The process is at the moment normally of the batch type and cannot be fully continuous, but only semi-continuous. The time-temperature cycle is important from the point of view of the economics of operation. It is possible to use hydrogen for heating up, and this will improve the rate of heat transfer and greatly improve the rate of cooling down. For brazing, it has been found that it is particularly useful for cooling, and reduces the cooling time by as much as 100 per cent, to have a small pressure of hydrogen, roughly 10 to 100 mm. Hg.

The total length of the furnace depends on the size of the furnace, and is directly related to the area. It is not possible to say more than that without knowing the size of the furnace in which interest is taken.

Dr. Jones wants to know something about the properties. Our work shows that it is possible to get very close to the wrought materials, as indicated in my conclusion.

Dr. Otto Winkler: The first question raised was how the shield elements could be kept to a sufficiently low temperature to allow re-evaporation of the material which has evaporated from the sintered body. This concerns materials such as titanium and niobium, where the preparation of the oxides is of importance for the removal of gases. In this case, either direct resistance heating of the sintered compact or indirect heating is used, perhaps by heater elements. Direct sintering is the best way. Next to the sintered body is the cool vacuum chamber. An indirect heating element in this case is not advised.

Regarding the leak rate of vacuum sintering plant, very clean conditions are necessary. The pumping equipment should be of relatively high speed and low vacuum. In pumping down, it must be possible to get a certain pressure in a definite time. If there is only a roughing pump, the ultimate vacuum suction speed becomes so low that differences in ultimate pressure are not so rapidly observed if a leak exists.

Another question was how to deoxidize copper oxide. The Paper says that the dissociation pressure of copper oxide at 1,000°C. is relatively low, so that it cannot be expected that copper oxide can be dissociated. It might be expected that at the melting point of copper the dissociation pressure would be sufficiently high, but we seem to get a copper which has an impurity of oxygen of about 0·001 per cent, and the activity of oxygen goes down in proportion to the concentration. At 1,000°C. there is a pressure of 10^{-5} mm. Hg., and there is still dissociation of the oxide of copper, so that even in this case it is not possible without reducing agents to deoxidize the copper. It has been reported that copper can be deoxidized in a ceramic crucible, presumably when reducing conditions in the atmosphere have prevailed. It may be that a roughing pump has been used or, alternatively, high oil pressure, or there was impurity in the crucible. Many studies have been made of the reduction of copper oxide, including using a ceramic crucible to see whether or not deoxidation in this way is possible. Because, theoretically, it would not be possible, the same test was made in another crucible which was pre-fired. It was found that the presence of small amounts of carbon as an impurity would reduce the copper.

Another question concerned the low dissociation pressure of iron oxide, about 10^{-13}, in view of the fact that in practice it is possible to sinter such material at a pressure of 10^{-3} mm. Hg. without difficulty. That is true. It is common practice to anneal stainless parts for television tube manufacture at a pressure of 10^{-3}-10^{-4} with success, though theoretically it should not be possible to remove the oxide layer. There are several reasons for this. One is that there is still a considerable carbon content in the material, and the other is that there is a monomolecular layer and there may be relatively low oxidation potentials; there are still hydrocarbons coming from the sealing elements, or from the pumps, which cancel the oxidation potential of the air which is dissolved from the surfaces or enters by leaks. It has been shown by Galbraith and Westinghouse in the U.S.A., by electron microscopy, that it is impossible to remove oxides on the surface even at pressures of 10^{-7}. It has been proved, therefore, that it is not possible to dissociate these oxides, but these layers are very thin, and in between the surface is clean, so that it may happen under these conditions that, even if no reducing conditions exist, at these points between the oxide islands sintering interaction is possible. That may be the reason why sintering is still possible.

T. R. Barrett: With regard to iron pick-up on milling, our experience is in agreement with that of Williams. The first two runs through a new mill produce some pick-up, but thereafter it is negligible. Wet milling has not been tried, but the milling which is done is in a pure argon atmosphere; other atmospheres, such as air and nitrogen, spoil the powder in many respects, and wet milling might be expected to do the same.

With regard to the reaction of the moulds and beryllium powder, some reaction does occur, as was pointed out, but in normal practice the powder sinters away from the walls of the mould before the reaction temperature is reached, so that the reaction with the walls is very small. There is more reaction on the base, but, after the mould has been used several times, it has a beryllium layer on the bottom which prevents further reaction. Graphite for the moulds is readily obtainable. Carbon has been

tried, but the reaction was rather vigorous. We have not tried adding weights or pressure during sintering. This would apparently bring it close to the conventional hot pressing techniques.

The vacuum maintained during the sintering is of the order of 1μ. The beryllium powder placed on top of the powder film reduces the weight loss considerably. In small-scale tests on 6 gm. samples of powder, the weight loss can be in the range 10-20 per cent. Pre-compacting the charge has not been tried, partly because any pre-compaction would probably cause a density difference from one part of the compact to another, and also the shrinkage would probably not be uniform. There seems no advantage in having a steel lining to the graphite mould.

For the small fuel elements which we made, two sources of uranium oxide were used, one from Williams at Harwell and the other from the Industrial Group at Risley. Whether the material from the Industrial Group was stoichiometric or not I do not know.

G. C. Ellis: With regard to sizes, which have not so far been mentioned, we have sintered blocks for rolling up to 4 in × 4 in × 10 in., and other shapes up to 12-13 in. diameter. These have densities in excess of 95 per cent. With regard to densities, an analysis of recent powder production, covering something of the order of 100 kg., shows that of this 100 kg. about 5 per cent has sintered to less than 90 per cent density, about 25 per cent to 90-95 per cent, and the remainder to over 95 per cent of the theoretical.

Pressureless sintered powder can be used in one of two ways: either directly in the machined condition for applications such as reflectors or moderators in reactors, or as a very useful starting material for fabricating to sheet or to tube. So far as the second application is concerned, experience has been that with fabricated powder products the use of material of a density slightly below the theoretical is an advantage rather than a disadvantage, so that a 95 per cent density is satisfactory for that purpose. With regard to the first use, the main advantage is that the properties in the sintered condition, and particularly the elongation, which is the paramount concern with beryllium, improve with the density. We have a certain critical size of powder which sinters. Our objective is to improve the process control so as to obtain regularly 100 per cent density, rather than accept 95 per cent.

Another point is that this is merely one range, or one particle size distribution. It remains to be discovered whether there are other particle size distributions which would be more readily obtainable in practice and which would confer better properties. The properties of beryllium depend very much on grain size, and grain size with beryllium is directly related to powder particle size; so that if another particle size distribution could be found, a finer size powder, better densities and better properties might be combined.

Welding has not been touched on but, using a modified argon arc welding technique, powder can be welded both in the sintered condition and in the sheet fabricating condition. A big difficulty in the welding or jointing of beryllium is to obtain a sound, crack-free joint, but by using a special argon arc technique this has been done.

Regarding the properties, the results came too late for inclusion in the Paper. The tensile property has been taken up to 600°C., first of all of the sintered metal as a function of density. The tensile elongation at room temperature is of the order of 5-6 per cent, and this is not improved by change of density from 93 per cent up to 99 per cent. The biggest change with density is at 400°C., where beryllium normally exhibits a peak ductility value. The elongations there are 15 per cent for 93-94 per cent density, 25 per cent for a density of 94-97 per cent, and 36 per cent elongation for a density of 97-99 per cent.

The main feature about the pressureless sintered material for use in fabrication, or for direct use in reactors, is that the material is isotropic and exhibits these properties in all directions. Beryllium is hexagonal, very susceptible on fabrication to preferred grain orientation, and this causes isotropy. With this preferred grain orientation and limited modes of deformation, when the material is rolled the properties are improved in the longitudinal direction, but only at the sacrifice of the transverse properties. This has now been rolled to sheet, and in one case the properties were improved so that creep occurs at 400°C. instead of 300°C., and a longitudinal elongation of 35 per cent has been obtained, and a transverse elongation of 45 per cent. It is obvious that in this case we have over cross-rolled. More recently, rolling at 800°C., the correct degree of cross-rolling was obtained, and, speaking from memory, we got a strength of the order of 45,000-50,000-lb/in^2 and an elongation, longitudinally and transversely, of 48-49 per cent.

J. Antill: A general question was raised about cracking. We obtained no cracking at all with metal compacts 1 in. in diameter and with a shrinkage of about 5-6 per cent, and also no cracking was obtained with ceramic articles 1 cm. in diameter and a shrinkage of about 15 per cent. Cracking problems were encountered, however, with ceramic tubes about 1 in. in diameter. It was found that the cracking became worse the thicker the tube. The problem was solved by slowing down the furnace speed. There was a critical furnace speed at which cracking was not obtained. This was quite reproducible from tube to tube, and once it was found no trouble occurred, but the limiting speed was lower the thicker the tube. The cracking appears to be due to thermal stresses and temperature gradients within the wire. This would explain why no trouble at all occurred with thick metal compacts with a much higher thermal conductivity. The suggestion which was made that the problem might be overcome by successive passes is, I think, correct. A series of passes while gradually increasing the maximum temperature is quite possible. We chose to solve it, however, by slowing furnace speeds.

Metal tubes have not been fabricated, but ceramic tubes have been made, and no trouble is foreseen in making metal tubes.

Lastly, Moors asked whether it would be suitable to obtain a green compact with a high strength by using a wax powder. This is quite possible, but a little care may be needed about one point. With the normal sintering operation, the wax is driven off before appreciable sintering is obtained. With this zone sintering technique, the metal is at a very high temperature, as well as a low one, and, therefore, wax and sintering material would be driven off at the same time, and one must make sure that the gaseous decomposition products of the wax do not react with the metal at the sintering temperature.

R. Edwards (Metal Cutanit Ltd.):

Barrett, Ellis and Knight mention that thin-walled tubes of high density have been produced, but that there is a tendency with increasing length to transverse cracking, and they add "This can be overcome." Have they any experience of making a ring of fairly thick wall thickness?

G. C. Ellis: Two things have essentially been done with regard to the sintering of tube. First, using small tubes, 1 in. in diameter and 1 in. high, the density of the tube was checked as a function of the I.D/O.D. ratio, and on this 1 in. basis it has been possible to sinter tubes down to wall thicknesses of about $\frac{1}{8}$ in. or just under, while retaining a density in excess of 93 per cent. In trying to make thinner tubes the density dropped disastrously, to 85-84 per cent. We are confident, therefore, that this technique is applicable to tubes of that wall thickness.

With regard to the use of the tube in fuel elements, it is necessary to retain impermeability to gases. In the Calder Hall reactor there is a gas coolant outside the tube, and inside a gaseous product. One does not want to have it seeping through and contaminating the gas stream, or the gas stream seeping through and oxidizing the fuel core.

Secondly, only two attempts to sinter tube of a larger size have been made. These were tubes 6-8 in. long with a wall thickness of about $\frac{3}{16}$ in. These tubes were made by sintering the powder round a graphite mandrel. Rectangular blocks of beryllium were made, the first being about 4 in × 4 in × 2 in. Working on the 20 per cent shrinkage rate which Barrett mentioned, we started with a cavity of about 5 in × 5 in × 2½ in., and that gave us spot-on dimensions. With a tube there is circumferential shrinkage and radial shrinkage. Density was referred to as a function of the I.D/O.D. ratio. The importance of that is that this ratio relates the ratio of the circumferential shrinkage to the thickness shrinkage, and when one is high with respect to the other there is cracking of the tube.

With a tube, if there is a binding of the tube on to the mandrel there is transverse cracking. It should be possible either by selecting the correct design of core or, better still, eliminating the core, to produce by pressureless sintering thin-walled tubes of about $\frac{1}{8}$ in. wall thickness and 12 in. long. The core would be used in the first place to form the powder. It should be possible to split the sleeve round the core, retract the core, and then let the shrinkage take place, and it would squeeze the tube.

The chairman then thanked the authors and contributors to the discussion, and declared the meeting closed.

Titanium in Toronto

IN last week's issue of METAL INDUSTRY, on page 514, the location of the new plant of the Titanium Metals Corporation of America was given as Toronto, Canada. This should, of course, have read Toronto, Ohio, U.S.A.

Industrial News *Home and Overseas*

New Technical Association

Serving the investment foundry industry using expendable pattern techniques for the production of industrial metal castings, a new technical association has been formed under the title of **The British Investment Casters' Technical Association.**

The objects and scope of the new organization are entirely devoted to technical aspects of investment casting, and will include such activities as the preparation of specifications for materials and testing procedures, the improvement of production techniques, expansion of the application of investment castings, and the general exchange of technical information within the industry.

At the inaugural meeting, held in London, which was attended by the representatives of 25 companies, the names of the founder-member companies were announced as follows:—Full members: The Birmingham Small Arms Co. Ltd., Close Tolerance Castings Ltd., Deritend Precision Castings Ltd., Firth-Vickers Stainless Steels Ltd., Hadfields Ltd., H. and F. Precise Castings Ltd., D. Napier and Son Ltd., and P.I. Castings (Altrincham) Ltd.

Associate members of the new association are: Astor Boissellier and Lawrence Ltd., Chambers Bros. Ltd., Claud Campbell and Co. Ltd., W. J. Hooker Ltd., Monsanto Chemicals Ltd., Samuel Osborn and Co. Ltd., Refractory Mouldings and Castings Ltd., Colin Stewart Ltd., Wilkins Campbell and Co. Ltd., and G. L. Willan Ltd.

During the inaugural meeting the following were elected as members of the Council:—**Mr. D. H. Armitage** (P.I. Castings (Altrincham Ltd.), as chairman; **Mr. R. W. N. Danielsen** (Deritend Precision Castings Ltd.), as vice-chairman; **Mr. W. Foyers** (H. and F. Precise Castings Ltd.), **Mr. G. A. Tomkinson** (D. Napier and Son Ltd.) and **Mr. N. Walker** (Hadfields Ltd.).

Through the courtesy of the B.S.C.R.A., the address of the newly-formed association will be 5 East Bank Road, Sheffield, 2, and Mr. J. Bolton has been appointed secretary. Companies interested in membership should write to Mr. Bolton for further particulars.

Change of Address

It has been announced by **Borax Ltd.** that, with effect from Monday next (June 30), the address of their Midlands branch sales office will be changed to Griffin House, 18-19 Ludgate Hill, Birmingham, 3, with the telephone number of Birmingham Central 2328.

Italian Copper Imports

It is reported by the Italian Statistical Office that in the first three months of this year, imports of crude copper for smelting and refining were 1,603·6 metric tons valued at 513,059,000 lire, of which 501·1 metric tons were temporarily imported. Main origins were Indonesia 101·3 metric tons and Chile 1,451·9 metric tons.

Imports of refined copper in slabs, ingots, granulated and powdered form were 19,682·9 metric tons valued at 6,291,658,000 lire, of which 3,110·7 metric tons were imported temporarily, and 197·9 metric tons were re-exported. Main origins were Britain's 2,206·3 metric tons; Belgian Congo 3,347·8; Chile, 3,712·2, and United States 5,275·6 metric tons.

Government Stockpile

In accordance with their announcements in December and January last, the Board of Trade have sold 6,700 tons of lead between January and June this year. There will be no further offerings of lead from the stockpile for the time being and an announcement will be made before sales are resumed.

Indian Copper Ore

Recent news from New Delhi is that the production of copper ore in India during the first quarter of this year was 94,144 tons, according to the Indian Bureau of Mines. The entire production came from the Singhbhum district of Bihar. The production of copper metal during the same period was 1,667 tons, as compared with 1,781 tons for the corresponding period of last year.

Bright Nickel Solution

We are informed by **R. Cruickshank Limited,** of Birmingham, that, as from Tuesday next, July 1, their association with the Electro Chemical Engineering Co. for the supply of Efco-Udylite bright nickel plating solution and brighteners will be discontinued.

As from that date they will supply "101" bright nickel plating solutions and brighteners by agreement with the Hanson Van Winkle-Munning Company, of America, and Dr. W. Kampschulte, of Germany. Their free installation and analysis service, backed by an augmented technical staff and research facilities, will operate throughout the country, and supplies and information will be available from the company's depots in Birmingham, London, Glasgow, Manchester, and Sheffield.

Machine Tool Demonstration

Organized by **Newman Industries Ltd.,** of Bristol, an interesting machine tool demonstration will be held at Manchester on July 9 and 10, the main purpose of which is to introduce to the British market a unique copying lathe by HEID. The machine has variable centre heights and several other new features of considerable interest to manufacturers.

A demonstrator from the HEID works at Vienna will explain the operation of the lathe, and copy turn an intricate component 7½ ft. long. Other machine tools imported from the Continent will also be displayed. Tickets for the demonstration may be obtained on application to the company at their headquarters, Yate, Bristol.

Change of Name

As from Monday next, June 30, the name of Aero Research Limited is to be changed to **CIBA (A.R.L.) Limited.** The company was formed in 1934 to pioneer research into aircraft structures, including the development of new adhesives.

In the last 20 years, the range and extent of the company's activities have radically changed, and the name is no longer appropriate in view of the many industries served by its products. It was, therefore, felt that the time was opportune to introduce a new name having associations with the past but emphasizing affiliation to the world-wide CIBA organization.

The trade names of "Aerolite," "Araldite," "Redux," and other proprietary products of the company will remain unaffected by the change of name.

Tin Council Meeting

It was announced by the International Tin Council on Friday of last week that it had "agreed formally to invite the Soviet Union to become a producer-participant in the International Tin Agreement." The announcement was made in a communique issued following a four-day meeting of the Council. The Council will meet again in London on July 22, when it will fix the total permissible tin exports for producer countries in the period October 1 to December 31, 1958.

At a press conference after the close of the Council meeting, Mr. Georges Peter said that he had been mandated by the Council to approach the Soviet Union asking them to join the agreement. "The U.S.S.R.," Mr. Peter said, "has always affirmed its desire to help underdeveloped countries, and its interest in international economic co-operation. By joining the Council, it will have the opportunity of putting these principles into practice. Such a move would, I am sure, be very much appreciated by all tin-producing countries."

Mr. Peter would not say whether any tentative approach had so far been made to the Soviet Union, but he stressed that this was the first time that the Council had "formally" agreed to invite the Russians to join. Asked if the Council had plans to apply any sanctions in the event of Russia refusing the invitation, Mr. Peter said: "You cannot conduct negotiations with a cudgel behind your back."

The communique issued by the Council said that the British Government had informed the Council that "no sales had been made from the United Kingdom Government stockpile of tin since the International Tin Agreement had entered into force, and that the United Kingdom Government had no intention of selling, or trying to sell, any of its stocks of tin for the time being."

On the question of fourth-quarter export control, Mr. Peter said that the Council had agreed in principle to maintain a system of control in this period. It would, however, fix the exact tonnage at its next meeting on July 22, when it had more precise information available to it, in particular relating to the trend of United States demand. The communique said the Republic of Korea had become a member of the I.T.A., and Korea's instrument of ratification has been formally deposited with the Council. Korea, as a consumer country, has been awarded seven votes on the Council.

The Council have elected Dr. Puey Ungphakorn (Thailand) as first vice-president, and Mr. Herinck (Netherlands) as second vice-president for the year beginning July 1, 1958.

Mr. W. F. Brazener, managing director of the company, laying the foundation stone of the new foundry of the Mint, Birmingham Ltd.

Foundation Stone Laid

An interesting ceremony took place at **The Mint, Birmingham, Limited,** on Thursday of last week when **Mr. W. F. Brazener,** J.P., managing director of the company, laid the foundation stone of the new foundry.

The Mint has been on this present site since 1860, and over the years the casting department has gradually found itself surrounded by extensions. The present building programme, which is the largest the company has contemplated for many years, is to house the new foundry in a more appropriate position than the existing one. This move will ultimately release more ground in the centre of the factory for future expansions.

An Exhibition in Bristol

In association with the Bristol Building Centre, the Building Centre of London is holding an exhibition of samples of recent new building materials in Stonebridge House, Colston Avenue, Bristol, from Tuesday, July 8, to Saturday, July 19, daily from 10 a.m. to 5.30 p.m. (Saturday 10 a.m. to 12.30 p.m.).

This will be an exhibition of samples and no manufacturers' representatives will be present, but members of the Bristol Building Centre technical staff will be present to answer enquiries. It is hoped to show about forty or fifty new products which have come on to the market in recent months.

News from Scotland

As part of the programme of re-location of Glasgow's population, **Archibald Low and Sons Ltd.,** of Partick, brassfounders, engineers and ships' plumbers, are moving to Kirkintilloch. Glasgow Corporation are co-operating in this move in order to facilitate transfer of population and industry to adjoining areas.

The Scottish Council (Development and Industry) have a new precision engineering project developing in Scotland. This is a watchmaking factory for an English company who are interested in establishing a branch factory in the Dundee area. Three other companies, Scottish, American and French, have been in touch with the Council with a view to locating branch factories. No details have yet been given of identities. Inverness Dean of Guild Court have also approved the erection of a new £12,500 factory on the Longman industrial estate, Inverness. Here, again, the identity of the firm has not been provided. Current projects involving Scottish manufacture include machine tools, non-skid gratings, industrial gas burners, industrial and aircraft filters, ash collectors, and a variety of similar products.

Pensions for Metal Workers

A works pension scheme of more than routine interest is being introduced by **John Allan and Company (Glenpark) Limited,** which has factories in Glasgow and Oldbury (Birmingham) for the manufacture of non-ferrous ingots. Pension schemes for hourly-paid factory workers are nowadays not uncommon; the features of Allans' scheme is that it has been specifically designed to meet the needs of a company employing a large proportion of casual labour.

Essential features of the scheme are:—(a) a pension at age 65 of one shilling a week for each year of service up to a maximum of £2 a week; for later retirement this figure will be increased; (b) a lump sum up to a maximum of £1,095 on death in service.

While there is a relatively long waiting period of five years before a workman becomes eligible (because of the high proportion of casual labour), pensions when payable will be calculated by reference to the whole period of service, including the waiting period.

The scheme will be non-contributory, the company having come to the conclusion that a contributory scheme would be liable to increase labour turnover in that some employees would change their jobs merely in order to be able to withdraw their contributions in cash. Allans is a member of the Metal Industries Group, which has a works pension fund covering most of its other companies.

U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week totalled 19,010 tons, comprising London 5,871; Liverpool 11,904, and Hull 1,235 tons. Copper stocks totalled 14,157 tons, and comprised London 8,499; Liverpool 5,368; Birmingham 75; Manchester 50, and Swansea 175 tons.

Fuel Efficiency

The fifth Refresher Course for Works Managers and Works and Plant Engineers organized by the National Industrial Fuel Efficiency Service, will be held, as usual, at the Clarendon Laboratory, Oxford, from September 22-26, 1958. Included in the subjects to be covered will be "Coal—The Future Trend in Production," "Oil—Industrial Application," "Use of Small Coal in Industry," "Industrial Use of Gas," "Electricity in Industry," "Boiler Efficiencies," "Steam Utilization," "Clean Air—Smoke Alarm Equipment," "Instrumentation," "Thermal Insulation." Fees: resident members £12 12s. 0d.; non-resident members £7 7s. 0d. Complete programme and further details may be obtained from the Secretary to the Course, Mr. E. S. Watkin, N.I.F.E.S., Ailsa House, 181 Kings Road, Reading, Berks.

A Selling Arrangement

It has been announced by **A. A. Jones and Shipman Limited,** Leicester, that from June 1 last they have acquired the sole selling rights for the "Matheys" range of jig boring machines for the U.K. and certain other territories. These machines, which are of Belgian manufacture, have a high reputation for accuracy and performance, whilst they are moderately priced.

The range comprises three types of machine, first the model 3A-2, which is a high-precision conventional jig boring machine; second, the 35-NC, a jig boring and vertical tool room milling machine equipped with optical or mechanical measuring system, suitable for the small workshop. The third is the SP-30 machine, which is similar to the above but smaller in capacity and without optical measuring equipment.

A specialized sales and service staff is available at Leicester to deal with all technical matters relating to these machines. This selling arrangement is a reciprocal one, as "Matheys" have been sole selling agents in Belgium, Luxemburg, and the Belgian Congo for a great number of years for all Jones-Shipman machine tools.

Australian Metal Exports

Speaking in Brisbane, Mr. John McEwen, the Australian Trade Minister, said recently that Australia's export trade in lead and zinc would have been seriously damaged if a United States Tariff Commission recommendation on higher barriers to imports of lead and zinc had been accepted. Mr. McEwen declared that more than half Australia's exports of lead and zinc had gone to the United States in 1956-57.

He was commenting on a statement by President Eisenhower that import tariffs on lead and zinc metals and ores would be frozen pending a Congressional study of the President's proposals for a subsidy to aid American lead and zinc mining

industries. Mr. McEwen said Australia would welcome action by the United States Government to provide an assured basis for the maintenance and expansion of economic production of lead and zinc.

Product Divisions

Two new divisions of **Associated Electrical Industries Ltd.** will become operative on Tuesday next (July 1). They are the A.E.I. Turbine-Generator Division, managed by Metropolitan-Vickers Electrical Company, and the A.E.I. Heavy Plant Division, managed by the British Thomson-Houston Company. These divisions will handle the design, manufacture and sales of all products falling within these categories.

These are the first A.E.I. divisions to be formed, following the chairman's announcement, at the time of the annual general meeting, of the proposed change to a divisional organization based on products. The headquarters of the Turbine-Generator Division will be at Trafford Park, Manchester, and of the Heavy Plant Division at Rugby.

Electronics Exhibition

One of the interesting stands which may be seen at the forthcoming Electronics Exhibition, to be held next month at the Manchester College of Technology, will be that occupied by **Baldwin Instrument Company Ltd.** Among the equipment which will be shown is the "Atomat" nucleonic thickness gauge with automatic standardization. This instrument is a standard Beta gauge to which has been added a new type of automatic standardizing unit designed to maintain the measuring instrument in close accuracy.

Then there will be the "Atomat" backscatter thickness gauge. Basically, the electronics of this equipment are identical to that used in the standard transmission gauge. The measuring head is designed in such a way that only one side of the material to be measured need be available. The only stipulation is that the other side of the material should be backed with a substance having a substantially different density and atomic number, e.g. rubber on a steel calender bowl, lacquer on zinc, etc. Another exhibit will be the protection electrometer and pocket ionization chamber. This is a very compact unit and constitutes a relatively accurate means of measuring stray X and gamma radiation. It is used in conjunction with the Baldwin protection electrometer, which is a reliable, easy-to-use charging and measuring device, calibrated directly in milliroentgens. These are only a few of the instruments which will be exhibited by the company on this occasion.

For Chrome Plating

A new lead alloy has recently been produced by **British Lead Mills Ltd.**, and is being marketed under the trade name of "Antatac R.I." The makers state that this alloy has been developed to counteract a small but increasing number of inexplicable failures in chrome tank linings. During tests it was found that this new alloy was not attacked by chrome plating solutions even when all the accepted rules for the protection of linings were deliberately broken, e.g. reversals of current, standing for months in cold solution, boiling away the solution, and addition of impurities.

This lead alloy is available in the form of sheet for linings and pipe for heating and cooling coils, and anodes. It is stated to be in use in Vauxhall Motors' new plating plant at Luton. British Lead Mills Ltd. is a member of the Firth Cleveland Group.

Tenders Called For

Tenders for two requirements are being called for by the Controller of Stores, Sudan Railways, Atbara, Sudan. The first concerns 150 tons of copper ingots, high grade, fire refined, minimum purity 99·88 per cent, in ingots of 25-27 kilos each. Tenders are to be delivered to the Controller of Stores not later than August 2, 1958, and prices should be based on both f.o.b. and c.i.f. Port Sudan per metric ton. Contract number 1789.

The second requirement, from the same source, is for the supply of 50 tons of bearing metal, ingot, white bronze. Details of the analysis of this metal can be obtained on application from the Controller of Stores, Atbara. Tenders are to be delivered by July 28, 1958, and prices should be quoted per metric ton on both f.o.b. and c.i.f. Port Sudan. Contract number 1787.

United States Stockpiling

A new programme of stockpiling for lead and zinc by the Government is being considered by the Senate interior sub-committee, according to Dow Jones. Sub-committee sources refused to give details of how much lead and zinc would be acquired under the plan. However, it was believed figures would roughly parallel a stockpiling programme for copper proposed earlier by the Administration which calls for up to 150,000 tons at a maximum price of 27½ cents a lb.

Men and Metals

It has been announced by English Metal Powder Company Limited that **Mr. E. A. Bird,** B.Sc. (Econ.), has been appointed export manager to the company. This appointment is stated to coincide with the opening by the company of a new plant which has been brought into operation to meet an increasing demand for its aluminium pastes and powders.

Nominations for new national officers for the American Society for Testing Materials, submitted at the annual meeting held at Boston, Mass., include the following: — **Frank L. LaQue,** vice-president and manager, Development and Research Division of The International Nickel Co. Inc., to continue as senior vice-president; **William L. Fink,** chief of the Physical Metallurgy Division of the Alcoa Research Laboratories, and **Alfred C. Webber,** senior supervisor, Experimental Station, E. I. du Pont de Nemours and Co., Inc., for three years on the board of directors. Also during the meeting, **Mr. Truman S. Fuller,** formerly engineer-in-charge of the works laboratory of The General Electric Company, and currently metallurgical consultant, will be honoured with a certificate of his election to honorary membership of the society.

Makers of temperature control equipment, West Instrument Limited announce the appointment of **Mr. J. C. Driver,** B.Sc. (Physics) as chief inspector. Mr. Driver was previously a production engineer at Mullards, where he was responsible for radio valve production.

A director of Blackburn and General Aircraft Limited, **Mr. A. F. Jopling,** A.C.A., has been appointed a director of Blackburn (Dumbarton) Limited, and Thomas Green and Sons Limited, of Leeds. Mr. Jopling is also chairman of the Lawley Group Limited, and a director of Adament and Western Engineering Limited.

News from John Allan and Company (Glenpark) Limited, one of the Metal Industries group of companies, is that **Mr. D. G. McCance** has been appointed secretary to the company.

Elected chairman of the North-West branch of the Institute of Metal Finishing for the 1958-59 session, **Mr. Adrian Walmsley,** who is 32 years of age, is North-Western representative of Silvercrown Limited. He served his apprenticeship in the metallurgical laboratory, with emphasis on process

control, of Rolls-Royce Limited, and subsequently became assistant manager, and later manager, of the plating department of Burco Limited. He was also a lecturer in metal finishing at Burnley Municipal College for four years.

In connection with the formation of the two new A.E.I. divisions, reported on this page, the following appointments have been made: To the Heavy Plant Division: **Mr. L. Drucquer** (divisional general manager), **Mr. L. D. Anscombe** (chief engineer), **Mr. C. W. Furniss** (manufacturing manager), **Mr. R. M. Grant** (commercial manager), and **Mr. N. R. D. Gurney** (divisional executive). To the Turbine-Generator Division: **Mr. R. J. Cochran** (general manager and commercial manager), **Dr. W. H. Darlington** (chief mechanical engineer), **Mr. W. N. Kilner** (chief electrical engineer), **Mr. R. R. Whyte** (manufacturing manager, Trafford Park), **Mr. D. R. S. Turner** (manufacturing manager, Larne), and **Mr. J. G. Boddy** (divisional executive).

Metal Market News

THE British Bureau of Non-Ferrous Metal Statistics has reported that usage of copper in April was up by about 2,500 tons to 55,506 tons, and inasmuch as this was a short working month, due to the Easter holiday, this result must be accounted as good. For the four months to April this year the total, at 216,741 tons, compared with 222,928 tons in the same period in 1957. Tin consumption advanced from 1,566 tons to 1,725 tons, to complete a four-month period total of 6,592 tons. In 1957, the comparable period accounted for 7,700 tons. Consumption of both lead and zinc declined in April, the former from 29,713 tons in March to 26,230 tons, and the latter from 26,967 tons to 24,984 tons. Over the four months' period lead was down by about 2,000 tons and zinc by about 3,000 tons. In the United States, the Copper Institute reported that U.S. domestic deliveries of copper declined in May to 78,631 short tons, while stocks of refined metal in producers' hands rose by nearly 2,400 tons to 253,463 short tons. The decline in deliveries was about 3,300 tons. Outside the U.S.A., deliveries were fully 5,500 tons up at 134,126 tons, while stocks fell by 5,000 tons to 244,778 short tons.

The news that the U.S. Government intends to stockpile some 150,000 tons of copper over 12 months, the metal being purchased at the market price with a maximum of 27½ cents, has completely transformed the appearance of standard copper in London, for in the course of a few days the price was rushed up to £200 and beyond it. Turnovers have been on a record-breaking scale, and a big proportion of the total has been done on the Kerb. During the week ending June 14, for example, something like 24,000 tons changed hands with a rise of £13 in the price of cash. Last week brought news of a further fall in L.M.E. warehouse stocks to 14,882 tons, and the market opened firm with both positions about £3 10s. 0d. higher, good business being reported with consumers on the Continent. Tin, however, was weak, the three months' price falling £6 10s. 0d. in the face of heavy selling believed to be in anticipation of possible developments at the Tin Council meeting in Paris. Monday's turnover was exceptionally high at 475 tons. A rally in the three months' price was seen on the following day.

In midweek it became known that the custom smelters who had previously advanced their copper price to 26 cents had gone up to 26½ cents, and that Anaconda had taken the bull by the horns and raised their selling limit to 26½ cents, it being obvious that Kennecott and Phelps Dodge would follow. The standard market was very firm on this news, and as much as £205 15s. 0d. was paid for three months, the day's turnover (Tuesday) being 5,400 tons. An announcement that Canada was cutting lead production sent the price up by 30s., while zinc was very firm at an advance of £1 15s. 0d. There has certainly been a marked change in sentiment on the Metal Exchange but this all-round rally, coming as it has just before the beginning of the holiday season of the year, even though quotations go higher than they are at present, can hardly fail in due course to lead to a sharp setback. Already in copper there have been heavy sales of the forward position, and further advances will doubtless lead to an intensification of this phenomenon. Early in the week a sharp fall was seen in the turnover on the New York copper futures market, and it may be that the market there will quieten down. On the other hand, those who have bought copper forward in New York can now see a very good profit, and selling may ensue.

New York

The Administration's proposal for stockpiling of copper for one year—the acquisition of 150,000 tons in that period at market prices up to 27½ cents per lb.—galvanized the copper market last week. Custom smelters raised their price to 26 cents per lb., and fabricators and, in turn, their customers stepped up their buying of electrolytic metal and copper products respectively.

Producers hesitated to raise their price, but Anaconda Sales Company increased the price of copper 1½ cents to 26½ cents. Other producers took no action, but custom smelters followed the advance and raised their price to 26½ cents per lb.

Producers at the 25 cents level had reported an improvement in fabricator buying, but this mainly reflected anticipatory purchases to beat any price increase. However, the producers continued to quote their price basis on date of shipment, as did fabricators in their sales of copper products. Some copper sources were surprised at the Anaconda price action, expecting producers to take a longer look at the market before advancing their price. However, it was hinted that Anaconda felt it had to match the L.M.E. price. These copper sources noted that copper wirebars, the material on which prices are based in the U.S., currently sell at a premium of 1 cent to 1½ cents per lb. on the British market. Anaconda is the largest copper producer in Chile, and its Chilean metal sold outside the U.S. is priced on the basis of the London Metal Exchange quotation.

Meanwhile, western lawmakers have introduced legislation to authorize the Administration's recently proposed copper stockpiling programme. The legislation was introduced in the Senate by the Interior Committee's chairman, Mr. Murray, and twelve other western Senators. It was sponsored by Mr. Metcalf and five other western Congressmen in the House. The programme is expected to cost as much as 82·5 million dollars for the one-year period.

Meanwhile, the lead and zinc industry has requested stockpile aid, but the Administration indicated some coolness to renewed stockpiling of lead and zinc, although Government officials did not rule it out. Tin was easier and quiet. Traders said Russian selling of tin abroad was creating price pressure on the metal.

Birmingham

The Midland unemployment rate, at 1·4 per cent against 2·1 for the country as a whole, is still the lowest in Britain, as it has been for a long time. A measure of caution is being shown as far as new enterprises are concerned, as is indicated by the applications for location approval for new industrial buildings. In the first five months of this year, approval was sought to build on only an additional 4·1 million ft², —nearly 20 per cent less than a year ago and 26 per cent less than in the same period of 1956. A recent survey by the Board of Trade says that Midland industry is still showing a considerable amount of optimism. This is probably due to the prosperity of the motor industry. Demand for certain electrical consumer goods has expanded, and the Government's road building programme has brought more work to Midland firms supplying machinery and materials.

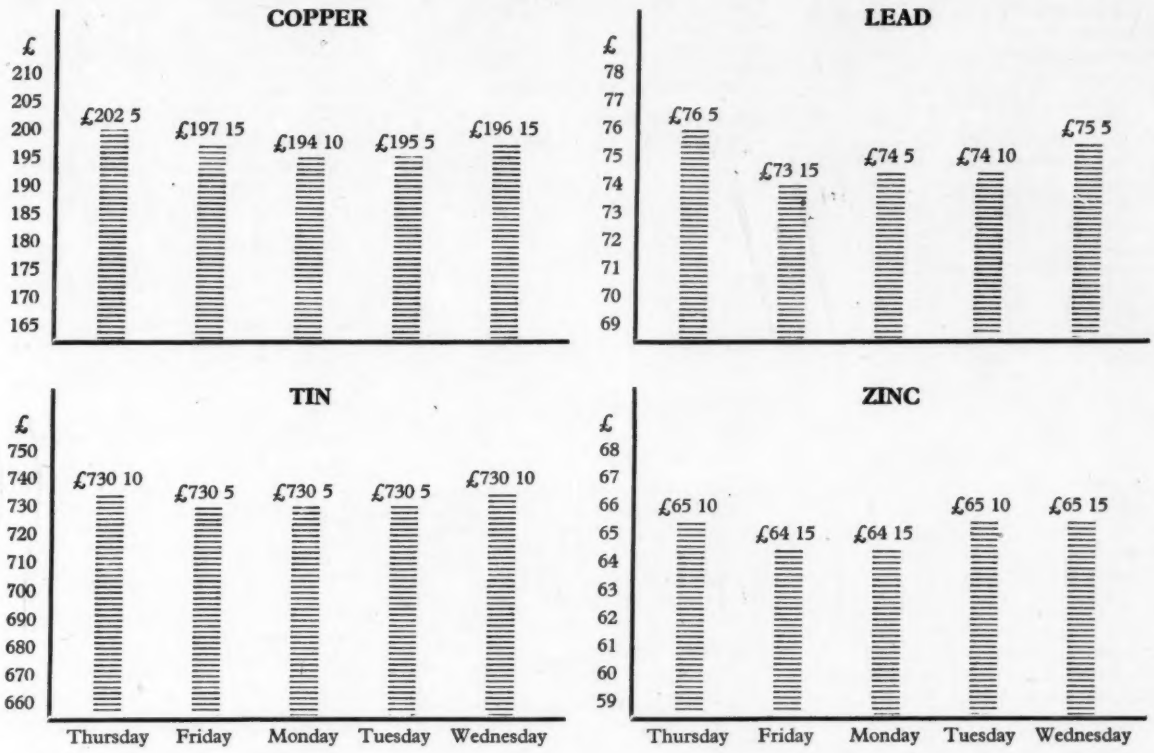
Now that steel products can be obtained without the long delays that have been experienced previously, consumers are only buying for early consumption. Stocks are still falling, and this process may continue for some months. Many of the re-rolling works are operating short time. The requirements of the motor trade as far as sheets and castings are concerned, are maintained at a high level. There is also a good trade in heavy castings for rolling stock and shipbuilding.

Madrid

By a decree published in the official bulletin, the Spanish Government has fixed a special tax of 1,500 pesetas per ton on zinc metal of Spanish origin to be added to the domestic consumer price. The money according from this tax will form a fund to help Spanish zinc mines, which are facing crisis in view of the low world prices for zinc.

METAL PRICE CHANGES

LONDON METAL EXCHANGE, Thursday 19 June 1958 to Wednesday 25 June 1958



OVERSEAS PRICES

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg ≏ £/ton	Canada c/lb ≏ £/ton	France fr/kg ≏ £/ton	Italy lire/kg ≏ £/ton	Switzerland fr/kg ≏ £/ton	United States c/lb ≏ £/ton
Aluminium		22.50 185 17 6	210 182 15	375 217 10		26.10 208 17 6
Antimony 99.0			195 169 12 6	430 249 10		29.00 232 0
Cadmium			1,500 1,305 0			155.00 1,240 0
Copper						
Crude						
Wire bars 99.9				400 232 0		
Electrolytic	28.50 208 7 6	24.00 198 5	257 223 10		2.30 192 7 6	25.00 200 0
Lead		10.50 86 15	110 95 15	184 106 15	.93 77 15	11.50 92 0
Magnesium						
Nickel		71.50 590 10	1,205 1,048 7 6	1,300 754 0	7.80 652 5	74.00 592 0
Tin	103.00 753 0		909 790 17 6	1,400 812 0	8.60 719 2 6	95.00 760 0
Zinc						
Prime western		10.00 82 12 6				10.00 80 0
High grade 99.95		10.60 87 10 0				
High grade 99.99		11.00 90 5				
Thermic			107.12 93 2 6			
Electrolytic			115.12 100 2 6	167 96 17 6	.82 68 10	11.25 90 0

NON-FERROUS METAL PRICES

(All prices quoted are those available at 12 noon 25/6/58)

PRIMARY METALS

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	„	197	0	0
Antimony Metal 99%	„	190	0	0
Antimony Oxide	„	180	0	0
Antimony Sulphide Lump	„	190	0	0
Antimony Sulphide Black Powder	„	205	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		10	0
Calcium	„	2	0	0
Cerium 99%	„	16	0	0
Chromium	„		6	11
Cobalt	„		16	0
Columbite per unit			—	
Copper H.C. Electro	ton	196	15	0
Fire Refined 99·70%	„	195	0	0
Fire Refined 99·50%	„	194	0	0
Copper Sulphate	„	70	0	0
Germanium	grm.		—	
Gold	oz.	12	9	11½
Indium	„		10	0
Iridium	„	22	0	0
Lanthanum	grm.		15	0
Lead English	ton	75	5	0
Magnesium Ingots	lb.		2	5½
Notched Bar	„		2	10½
Powder Grade 4	„		6	3
Alloy Ingot, A8 or AZ91	„		2	8
Manganese Metal	ton	300	0	0
Mercury	flask	76	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.		nom.	
Osmiridium	„		nom.	
Palladium	„		5 15	0
Platinum	„		25 0	0
Rhodium	„		40 0	0
Ruthenium	„		16 0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	3
Tellurium	lb.		15	0
Tin	ton	730	10	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	65	15	0
Dust 95/97%	„	104	0	0
Dust 98/99%	„	110	0	0
Granulated 99+%	„	90	15	0
Granulated 99·99+%	„	103	11	3

**Duty and Carriage to customers' works for buyers' account.*

INGOT METALS

Aluminium Alloy (Virgin)		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	„	202	0	0
B.S. 1490 L.M.7	„	216	0	0
B.S. 1490 L.M.8	„	203	0	0
B.S. 1490 L.M.9	„	203	0	0
B.S. 1490 L.M.10	„	221	0	0
B.S. 1490 L.M.11	„	215	0	0
B.S. 1490 L.M.12	„	223	0	0
B.S. 1490 L.M.13	„	216	0	0
B.S. 1490 L.M.14	„	224	0	0
B.S. 1490 L.M.15	„	210	0	0
B.S. 1490 L.M.16	„	206	0	0
B.S. 1490 L.M.18	„	203	0	0
B.S. 1490 L.M.22	„	210	0	0

		£	s.	d.
†**Aluminium Alloy (Secondary)**				
B.S. 1490 L.M.1	ton	151	0	0
B.S. 1490 L.M.2	„	158	0	0
B.S. 1490 L.M.4	„	179	0	0
B.S. 1490 L.M.6	„	195	0	0

†Average selling prices for April

***Aluminium Bronze**				
BSS 1400 AB.1	ton	203	0	0
BSS 1400 AB.2	„	200	0	0
***Brass**				
BSS 1400-B3 65/35	„	138	0	0
BSS 249	„		—	
BSS 1400-B6 85/15	„		—	
***Gunmetal**				
R.C.H. 3/4% ton	ton		—	
(85/5/5/5)	„	168	0	0
(86/7/5/2)	„	178	0	0
(88/10/2/1)	„	232	0	0
(88/10/2/½)	„	239	0	0
Manganese Bronze				
BSS 1400 HTB1	„	169	0	0
BSS 1400 HTB2	„		—	
BSS 1400 HTB3	„		—	
Nickel Silver				
Casting Quality 12%	„		nom.	
„ „ 16%	„		nom.	
„ „ 18%	„		nom.	
***Phosphor Bronze**				
2B8 guaranteed A.I.D. released	„	258	0	0
Phosphor Copper				
10%	„	228	0	0
15%	„	237	0	0

**Average prices for the last week-end.*

Phosphor Tin				
5%	ton		—	
Silicon Bronze				
BSS 1400-SB1	„		—	
Solder, soft, BSS 219				
Grade C Tinmans	„	350	6	0
Grade D Plumbers	„	285	0	0
Grade M	„	383	3	0
Solder, Brazing, BSS 1845				
Type 8 (Granulated)	lb.		—	
Type 9	„		—	
Zinc Alloys				
Mazak III	ton	96	16	3
Mazak V	„	100	16	3
Kayem	„	106	16	3
Kayem II	„	112	16	3
Sodium-Zinc	lb.		2	5

SEMI-FABRICATED PRODUCTS

Prices of all semi-fabricated products vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium			£	s.	d.
Sheet	10	S.W.G. lb.		2	8
Sheet	18	S.W.G. „		2	10
Sheet	24	S.W.G. „		3	1
Strip	10	S.W.G. „		2	8
Strip	18	S.W.G. „		2	9
Strip	24	S.W.G. „		2	10½
Circles	22	S.W.G. „		3	2
Circles	18	S.W.G. „		3	1
Circles	12	S.W.G. „		3	0
Plate as rolled		„		2	7½
Sections		„		3	1½
Wire 10 S.W.G.		„		2	11
Tubes 1 in. o.d. 16 S.W.G.		„		4	0

		£	s.	d.
Aluminium Alloys				
BS1470. HS10W. lb.				
Sheet 10 S.W.G.	„		3	0½
Sheet 18 S.W.G.	„		3	3
Sheet 24 S.W.G.	„		3	10½
Strip 10 S.W.G.	„		3	0½
Strip 18 S.W.G.	„		3	2
Strip 24 S.W.G.	„		3	10
BS1477 HP30M.				
Plate as rolled	„		2	10½
BS1470. HC15WP.				
Sheet 10 S.W.G.	lb.		3	6½
Sheet 18 S.W.G.	„		4	0½
Sheet 24 S.W.G.	„		4	10½
Strip 10 S.W.G.	„		3	9½
Strip 18 S.W.G.	„		4	0½
Strip 24 S.W.G.	„		4	8
BS1477. HPC15WP.				
Plate heat treated	„		3	5½
BS1475. HG10W.				
Wire 10 S.W.G.	„		3	9½
BS1471. HT10WP.				
Tubes 1 in. o.d. 16 S.W.G.	„		4	11
BS1476. HE10WP.				
Sections	„		3	1
Beryllium Copper				
Strip	„	1	4	11
Rod	„	1	1	6
Wire	„	1	4	9
Brass Tubes	„		1	6⅞
Brazed Tubes	„		—	
Drawn Strip Sections	„		—	
Sheet	ton		—	
Strip	„	222	15	0
Extruded Bar	lb.		1	9½
Extruded Bar (Pure Metal Basis)	„		—	
Condenser Plate (Yellow Metal)	ton	160	0	0
Condenser Plate (Naval Brass)	„	171	0	0
Wire	lb.		2	4½
Copper Tubes	lb.		1	11⅞
Sheet	ton	222	10	0
Strip	„	222	10	0
Plain Plates	„		—	
Locomotive Rods	„		—	
H.C. Wire	„	248	5	0
Cupro Nickel				
Tubes 70/30	lb.		3	3⅞
Lead Pipes (London)	ton	115	0	0
Sheets (London)	„	112	15	0
Tellurium Lead	„	£6 extra		
Nickel Silver				
Sheet and Strip 7%	„		3	3¼
Wire 10%	„		3	10¼
Phosphor Bronze				
Wire	„		3	8¼
Titanium (10,000 lb. lots)				
Billet 11″-4″	lb.	69/-	60/-	
Wire ·315″-·036″	„	101/-	201/-	
Sheet (4′/8′ × 2′) ·160″-·010″	„	100/-	158/-	
Strip ·048″-·003″	„	100/-	350/-	
Tube Representative gauge	„	320/-		
Extrusions	„	137/-		
Zinc Sheets, English destinations	ton	99	5	0
Strip	„	nom.		

Scrap Metal Prices

Merchants' average buying prices delivered, per ton, 24/6/58.

	£
Aluminium	
New Cuttings	135
Old Rolled	110
Segregated Turnings	90
Brass	
Cuttings	119
Rod Ends	117
Heavy Yellow	102
Light	97
Rolled	112
Collected Scrap	100
Turnings	110
Copper	
Wire	165
Firebox, cut up	165
Heavy	158
Light	153
Cuttings	165
Turnings	150
Braziery	130
Gunmetal	
Gear Wheels	160
Admiralty	160
Commercial	134
Turnings	129
Lead	
Scrap	67
Nickel	
Cuttings	—
Anodes	445
Phosphor Bronze	
Scrap	134
Turnings	135
Zinc	
Remelted	56
Cuttings	43
Old Zinc	32

The latest available scrap prices quoted on foreign markets are as follow. (The figures in brackets give the English equivalents in £1 per ton):—

West Germany (D-marks per 100 kilos):		
Used copper wire	(£169.12.6)	195
Heavy copper	(£169.12.6)	195
Light copper	(£148.0.0)	170
Heavy brass	(£108.15.0)	125
Light brass	(£82.12.6)	95
Soft lead scrap	(£62.12.6)	72
Zinc scrap	(£36.10.0)	42
Used aluminium unsorted	(£87.0.0)	100
France (francs per kilo):		
Copper	(£217.10.0)	250
Heavy copper	(£217.10.0)	250
Light brass	(£148.0.0)	170
Zinc castings	(£65.5.0)	75
Tin	(£565.10.0)	650
Aluminium pans (98½ per cent)	(£117.10.0)	135
Italy (lire per kilo):		
Aluminium soft sheet clippings (new)	(£191.10.0)	330
Aluminium copper alloy	(£107.7.6)	185
Lead, soft, first quality	(£85.17.6)	148
Lead, battery plates	(£50.10.0)	87
Copper, first grade	(£188.10.0)	325
Copper, second grade	(£177.0.0)	305
Bronze, first quality machinery	(£188.10.0)	325
Bronze, commercial gunmetal	(£159.10.0)	275
Brass, heavy	(£133.10.0)	230
Brass, light	(£121.17.6)	210
Brass, bar turnings	(£130.10.0)	225
New zinc sheet clippings	—	—
Old zinc	—	—

Financial News

A. E. Griffiths (Smethwick) Ltd.

Final dividend 15 per cent, making 22½ per cent year to March 31, 1958 (same equivalent). Group profit £133,510 (£129,610). To directors' remuneration £12,211 (£15,401), tax £59,895 (£57,783), leaving £61,404 (£56,426).

Amalgamated Metal Corporation

Consolidated balance sheet as at December 31, 1957, shows total assets £15,171,858 (£17,972,318). Current assets £12,912,361 (£15,627,460), included cash £863,624 (£1,034,213), debtors £6,703,189 (£9,136,217), and stocks £3,366,991 (£3,332,963). Profit for 1957 before taxation £1,023,375. Proposed final dividend of 6 per cent, making 9 per cent for year.

General Refractories Ltd.

The directors have decided to issue 500,000 Ordinary shares of 10s. each at 26s. 6d. per share and to offer them to Ordinary shareholders registered on June 6, 1958, in the proportion of one new share for every five Ordinary shares then held. The proceeds of the issue will be applied in repaying bank overdrafts and towards a programme of further development.

The Ordinary shares now being issued will rank *pari passu* with the existing Ordinary shares. The directors are of the opinion that, provided group turnover for the remainder of 1958 continues at the level achieved to date, and provided no unforeseen event occurs, they will be able to recommend for the current year the same rate of dividend on the increased capital as was paid in respect of 1957, i.e. 20 per cent less income tax.

London Tin Corporation

Group net profit for year to March 31, 1958, £686,096 (£732,933 for 11 months). Parent's dividends from investments, etc., £1,358,418 (£1,415,269 for 11 months), plus profits, less losses, on investments £47,599 (£17,732), less general expenses £70,175 (£63,560), mining projects, etc., expenditure £5,074 (£2,715). To tax £686,000 (£652,000), leaving net income £644,768 (£714,726). Dividends, already known, 30 per cent (same), group current assets £6,402,342 (£6,431,237), including quoted investments £5,265,325 (£5,267,707), with market value £7,403,874 and cash £637,845 (£472,345). Current liabilities £769,439 (£818,002), and provisions £156,459 (£156,314). Capital reserves £376,934 (same), revenue reserves £1,843,813 (£1,781,863), and future tax £47,411 (£92,235).

Trade Publications

Noral Stress-Relieved Plate. — Northern Aluminium Company Ltd., Banbury, Oxon.

This booklet is intended to provide designers with information on the properties, sizes, manufacturing tolerances, and inspection standards to which this stress-relieved plate is produced. There are many tables and other details contained within the booklet's 16 pages.

Extrusion Press Components.—Hadfields Ltd., East Hecla Works, Sheffield.

Within the 24 pages of this latest brochure is contained details and photographs of the extrusion press components from this Sheffield company. Detailed are containers, liner holders, liners, rams, dies, die holders, bolsters, mandrels, pressure pads, scraper plates, crosshead castings, and the like.

Auto-Titration Equipment. — Baird and Tatlock (London) Ltd., Chadwell Heath, Essex.

This eight-page brochure sets out to show how "Analmatic" auto-titration equipment can cover a wide variety of titrations, including those involving *p*H and "dead-stop" end-points. The results of the titration are usually recorded in digital form, but if required chart recording can be provided. Particular applications of this equipment will probably differ appreciably, and only a general description of the features available is given in this brochure.

Conveyor and Elevator Belting.—B.T.R. Industries Ltd., Herga House, Vincent Square, London S.W.1.

A well-produced loose-leaf booklet, covering 52 pages, devoted to details, data, diagrams and illustrations of the conveyor and elevator belting, and accessories, produced by this company.

Welding Equipment. — Suffolk Iron Foundry (1920) Ltd., Sifbronze Works, Stowmarket, Suffolk.

An eight-page booklet describes and illustrates all the main items of Sifbronze welding equipment—gas regulators, blowpipes, etc.—and makes particular mention of the "Demon" cutter, which is the latest addition to the Sifbronze range.

Good Colour. — Imperial Chemical Industries Limited, Paints Division, Slough, Bucks.

With this title is published a most artistic booklet providing in 16 pages an introduction to the services of the colour advisory department of the Division. The illustrations of the various public and industrial buildings given are all in colour and provide a satisfying impression of some of the many colour schemes which the firm has prepared. This booklet should be useful to industrialists, architects, and others responsible for providing buildings to house workers, machinery, schools, and the like.

Non-Destructive Testing. — Solus-Schall Limited, 15-18 Clipstone Street, London, W.1.

The latest available issue of the S.S. News (No. 9) deals mainly with the subject of non-destructive testing and includes articles on ultrasonic testing, the summer school on non-destructive testing, etc. There are articles on Voltage Drop, and the Ultrasonic Beam in Immersion Technique.

THE STOCK EXCHANGE

Prices Showed Further Improvement

ISSUED CAPITAL •	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 24 JUNE +RISE —FALL		DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1958 HIGH	1958 LOW	1957 HIGH	1957 LOW
£	£				Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	20/6xd	+7½d.	9	10	8 15 6	21/3	17/9	28/3	18/–
400,000	2/–	Anti-Attrition Metal	1/6		4	8½	5 6 9	1/6	1/3	2/6	1/6
33,639,483	Stk. (£1)	Associated Electrical Industries ...	49/9	+1/3	15	15	6 0 9	51/–	47/–	72/3	47/9
1,590,000	1	Birfield Industries	49/6	+1/–	15	15	6 1 3	53/9	46/3	70/–	48/9
3,196,667	1	Birmid Industries	67/–	+9d.	17½	17½	5 4 6	68/–	56/3	80/6	55/9
5,630,344	Stk. (£1)	Birmingham Small Arms	28/1½	+1½d.	10	8	7 2 3	28/6	23/9	33/–	21/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/4½		5	5	6 10 0	15/7½	14/7½	16/–	15/–
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	16/7½		6	6	7 4 3	17/–	16/6	19/–	16/6
500,000	1	Bolton (Thos.) & Sons	25/–	—1/3	12½	12½	10 0 0	28/9	25/–	30/3	28/9
300,000	1	Ditto Pref. 5%	15/6	+3d.	5	5	6 9 0	16/–	15/3	16/9	14/3
160,000	1	Booth (James) & Co. Cum. Pref. 7%	19/–xd		7	7	7 7 3	19/3	19/–	22/3	18/9
9,000,000	Stk. (£1)	British Aluminium Co.	44/–	+1/–	12	12	5 9 0	46/6	37/–	72/–	38/3
1,500,000	Stk. (£1)	Ditto Pref. 6%	19/–		6	6	6 6 3	19/3	18/4½	21/6	18/–
15,000,000	Stk. (£1)	British Insulated Callender's Cables	44/9	—9d	12½	12½	5 11 9	45/6	38/9	55/–	40/–
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord. ...	35/3	+2/9	10	10	5 13 6	35/3	29/–	39/–	29/6
600,000	Stk. (5/–)	Canning (W.) & Co.	20/–	+4½d.	25+*2½C	25	6 5 0	21/–	19/7½	24/6	19/3
60,484	1/–	Carr (Chas.)	1/9		25	25	10 0 0X	2/3	1/9	3/6	2/1½
150,000	2/–	Case (Alfred) & Co. Ltd.	4/3		25	25	11 16 3	4/9	4/1½	4/6	4/–
555,000	1	Clifford (Chas.) Ltd.	17/9	+3d.	10	10	11 5 3	17/9	16/–	20/6	15/9
45,000	1	Ditto Cum. Pref. 6%	15/7½xd		6	6	7 13 9	15/10½	15/7½	17/6	16/–
250,000	2/–	Coley Metals	2/9		20	25	14 11 0	4/6	2/9	5/7½	3/9
8,730,596	1	Cons. Zinc Corp.†	48/6	+1/6	18¾	22½	7 14 6	51/6	42/6	92/6	49/–
1,136,233	1	Davy & United	50/6	+6d.	15	12½	5 18 9	50/6	45/9	60/6	42/6
2,750,000	5/–	Delta Metal	20/3	+3d.	30	*17½	7 8 3	21/4½	17/7½	28/6	19/–
4,160,000	Stk. (£1)	Enfield Rolling Mills Ltd.	34/–	+6d.	12½	15B	7 7 0	34/–	24/–	38/6	25/–
750,000	1	Evered & Co.	27/6xcap		15Z	15	7 5 6	28/3	26/–	52/9	42/–
18,000,000	Stk. (£1)	General Electric Co.	33/6	+2/–	12½	14	6 17 3Y	38/7½	29/6	59/–	38/–
1,500,000	Stk. (10/–)	General Refractories Ltd.	32/9	+2/9	20	17½	6 2 3	33/9	27/3	37/–	26/9
401,240	1	Gibbons (Dudley) Ltd.	65/–		15	15	4 12 3	66/3	64/–	71/–	53/–
750,000	5/–	Glacier Metal Co. Ltd.	6/–xd		11½	11½	9 11 9	6/6	5/7½	8/1½	5/10½
1,750,000	5/–	Glynwed Tubes	13/9	+1½d.	20	20	7 5 6	13/9	12/10½	18/–	12/6
5,421,049	10/–	Goodlass Wall & Lead Industries ...	24/6	+1/–	13‖	18Z	5 6 0	24/6	19/3	37/3	28/9
342,195	1	Greenwood & Batley	46/9		20	17½	7 9 9	46/10½	45/–	50/–	46/–
396,000	5/–	Harrison (B'ham) Ord.	13/3	+7½d.	*15	*15	5 13 3	13/3	11/6	16/9	12/4½
150,000	1	Ditto Cum. Pref. 7%	18/9		7	7	7 9 3	19/–	18/9	22/3	18/7½
1,075,167	5/–	Heenan Group	7/3		10	20‡	6 18 0	7/7½	6/9	10/4½	6/9
142,045,750	Stk. (£1)	Imperial Chemical Industries ...	44/9	+6d.	12Z	10	5 7 3	44/10½	36/6	46/6	36/3
33,708,769	Stk (£1)	Ditto Cum. Pref. 5%	16/7½	+6d.	5	5	6 0 3	17/1½	16/–	18/6	15/6
14,584,025	**	International Nickel	144½	—2½	$3.75	$3.75	4 12 6	148½	132‡	222	130
430,000	5/–	Jenks (E. P.), Ltd.	8/1½	—1½d.	27½¢	27½	8 9 3	8/3	6/9	18/10½	15/1½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	16/3		5	5	6 3 0	16/3	15/–	17/–	14/6
3,987,435	1	Ditto Ord.	45/6	+6d.	10	9	4 8 0	45/6	37/6	58/9	40/–
600,000	10/–	Keith, Blackman	17/6		15	15	8 11 6	17/6	15/–	21/9	15/–
160,080	4/–	London Aluminium	4/1½		10	10	9 14 0	4/3	3/–	6/9	3/6
2,400,000	1	London Elec. Wire & Smith's Ord. ...	45/–	+3d.	12½	12½	5 11 0	45/–	39/9	54/6	41/–
400,000	1	Ditto Pref.	23/3xd	+4½d.	7½	7½	6 9 0	23/3	22/3	25/3	21/9
765,012	1	McKechnie Brothers Ord.	32/6		15	15	9 4 6	35/–	32/–	48/9	37/6
1,530,024	1	Ditto A Ord.	31/3		15	15	9 12 0	32/6	30/–	47/6	36/–
1,108,268	5/–	Manganese Bronze & Brass	9/6		20	27½‡	10 10 6	10/6	9/–	21/10½	7/6
50,628	6/–	Ditto (7½% N.C. Pref.)	6/–		7½	7½	7 10 0	6/3	5/9	6/6	5/–
13,098,855	Stk. (£1)	Metal Box	51/6xd	+9d.	11	11	3 17 9	51/6	41/9	59/–	40/3
415,760	Stk. (2/–)	Metal Traders	7/1½	+1½d.	50	50	14 0 9	7/1½	6/3	8/–	6/3
160,000	1	Mint (The) Birmingham	20/–		10	10	10 0 0	22/9	20/–	25/–	21/6
80,000	5	Ditto Pref. 6%	81/6		6	6	7 7 6	83/6	81/6	90/6	83/6
3,064,930	Stk. (£1)	Morgan Crucible A	38/–xd		10	10	5 5 3	40/–	34/–	54/–	35/–
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	17/–		5½	5½	6 9 6	17/3	17/–	19/3	16/–
2,200,000	Stk. (£1)	Murex	58/9	+3/6	20	20	6 16 3	58/9	53/3	79/9	57/–
468,000	5/–	Ratcliffs (Great Bridge)	8/7½		10	10	5 16 0	8/7½	6/10½	8/–	6/10½
234,960	10/–	Sanderson Bros. & Newbould ...	25/9		20	27½D	7 15 3	27/–	25/6	41/–	24/9
1,365,000	Stk. (5/–)	Serck	13/3	+6d.	17½Z	15	4 8 0	13/3	11/–	18/10½	11/6
600,400	Stk. (£1)	Stone (J.) & Co. (Holdings)	51/3	+3/9	16	16	6 4 9	51/3	43/9	57/6	43/9
600,000	1	Ditto Cum. Pref. 6½%	19/6xd	+3d.	6½	6½	6 13 3	20/9	19/6	21/9	18/9
14,494,862	Stk. (£1)	Tube Investments Ord.	54/9		15	15	5 9 6	55/9	48/4½	70/9	50/6
41,000,000	Stk. (£1)	Vickers	30/–	+1/3	10	10	6 13 3	32/6	28/9	46/–	29/–
750,000	Stk. (£1)	Ditto Pref. 5%	15/–		5	5	6 13 3	15/6	14/9	18/–	14/–
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	21/3		*5	*5	7 4 9A	23/–	21/3	24/9	20/7½
2,200,000	1	Ward (Thos. W.), Ord.	77/3	+1/6	20	15	5 3 6	77/3	70/9	83/–	64/–
2,666,034	Stk. (£1)	Westinghouse Brake	40/–	+3d.	10	18P	5 0 0	40/–	32/6	85/–	29/1½
225,000	2/–	Wolverhampton Die-Casting ...	7/1½		25	40	7 0 3	8/–	7/1½	10/1½	7/–
591,000	5/–	Wolverhampton Metal	17/7½	+4½d.	27½	27½	7 16 0	17/7½	14/9	22/3	14/9
78,465	2/6	Wright, Bindley & Gell	3/6		20	17½E	14 5 9	3/9½	3/3	3/9	2/7½
124,140	1	Ditto Cum. Pref. 6%	11/3xd		6	6	10 13 3	11/6	11/3	12/6	11/3
150,000	1/–	Zinc Alloy Rust Proof	3/1½	+3d.	40D	33½	8 10 9	3/1½	2/7½	5/–	2/9

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting **Shares of no Par Value. ‡ and 100% Capitalized Issue. •The figures given relate to the issue quoted in the third column. A Calculated on £7 14 6 gross. Y Calculated on 11½% dividend. ‖Adjusted to allow for capitalization issue. E for 15 months. P and 100% capitalized issue, also "rights" issue of 2 new shares at 35/– per share for £3 stock held. D and 50% capitalized issue. Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. ¢ And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits.

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